TECHNICAL REPORT
NATICK/TR-17/022

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SUSTAINABILITY LOGISTICS BASING – SCIENCE AND TECHNOLOGY OBJECTIVE – DEMONSTRATION; DEMONSTRATION #1 – 50 PERSON CAMP DEMO

by

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August 2017

Final Report
September 2014 – October 2014

Approved for public release; distribution is unlimited

U.S. Army Natick Soldier Research, Development and Engineering Center
Natick, Massachusetts 01760-5000

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14. ABSTRACT

During the period from 29 September - 17 October 2014, the U. S. Army Natick Soldier Research, Development and Engineering Center (NSRDEC) collected data on technologies related to the objectives of the SLB-STO-D at the Base Camp Integration Laboratory (BCIL), Fort Devens, MA. The goal of the SLB-STO-D is to demonstrate through operationally relevant field experimentation and subsequent analysis that emerging materiel solution technologies and associated non-materiel solutions can reduce the need for fuel resupply by 25%, for water resupply by 75%, and for waste removal by 50%, while maintaining or improving the quality of life at expeditionary base camps in the size range of 50-1000 personnel. The SLB-STO-D is using modeling and simulation, closely integrated with field demonstrations, to show fuel, water, and waste savings attributed to these technologies. Technologies demonstrated in Demo 1 at the BCIL include: Expedient Shelters with Non-woven Composite Insulation Liner (LINER); 1kWe JP-8 Fueled, Man-Portable GenSet (MANGEN); Renewable Energy for Distributed Under-supplied Command Environments (REDUCE); and Bidirectional Onboard Vehicle Power/Tactical Vehicle-to-Grid Module (OBVP/TV2GM). This Technical Report documents the objectives, technologies, methods, and results of the Demonstration #1 venue at the BCIL.

15. SUBJECT TERMS

FUELS LOGISTICS ENVIRONMENTS REDUCED FOOTPRINT DEMONSTRATIONS
WASTE BASE CAMPS SUSTAINABILITY RENEWABLE ENERGY WASTE REDUCTION
WATER REDUCTION WASTE DISPOSAL ENERGY CONSUMPTION DATA COLLECTION
ENERGY INSULATION EXPEDIENT SHELTERING WATER DEMAND REDUCTION
SAVINGS WASTE WATER CONTINGENCY BASING MODELING AND SIMULATION
GENSETS SOLID WASTES FUEL DEMAND REDUCTION ENVIRONMENTAL MANAGEMENT
FEEDBACK ELECTRIC POWER BCIL(BASE CAMP INTEGRATION LABORATORY)
TECD(TECHNOLOGY ENHANCED CAPABILITY DEMONSTRATION)

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PREFACE

The Sustainability/Logistics-Basing Science and Technology Objective – Demonstration (SLB-STO-D) Experimentation, Demonstration, and Validation Team (EDVT), supported by the functional teams of the SLB-STO-D, conducted the first installment of Demonstration #1 during the period 29 September - 17 October 2014 at the Base Camp Integration Laboratory (BCIL), Fort Devens, MA to collect data on technologies that support the objectives of the SLB-STO-D. This event, was born out of the execution of the approved Project Plan (version 3.0, dated 19 April 2013), the Integrated Master Schedule (IMS), and the Systems Engineering Plan (SEP). This report fully supports the directives established therein to document the objectives, materials, technologies, methods and results of data collection events in support of the SLB-STO-D. Datasets associated with this demonstration were delivered to the SLB-STO-D's Lead Systems Engineer and are summarized in this report. Other functional teams, such as the Modeling, Simulations, and Analysis Team, will use the data collected during this demonstration to conduct analysis related to the SLB-STO-D objectives and publish those findings and results under a separate cover.

The work was performed in collaboration with:

- RDECOM
    - US Army Natick Soldier Research, Development and Engineering Center (NSRDEC)
    - Communications-Electronics Research, Development and Engineering Center (CERDEC)
    - Tank and Automotive Research, Development and Engineering Center (TARDEC)
    - Army Research Laboratory (ARL)
    - Armament Research, Development and Engineering Center (ARDEC)
- US Army Corps of Engineers
    - Engineer Research and Development Center (ERDC), Construction Engineering Research Laboratory (CERL)
- Program Executive Office Combat Support and Combat Service Support (PEO CS & CSS)
    - Program Manager Expeditionary, Energy and Sustainment Systems (PM E2S2)
    - Product Manager Force Sustainment Systems (PdM FSS)
    - Product Manager Petroleum and Water Systems (PdM PAWS)
    - Product Directorate Manager Contingency Basing Infrastructure (PdD CBI)
- Training and Doctrine Command (TRADOC)
    - Maneuver Support Center of Excellence (MSCoE)
    - Combined Arms Support Center (CASCOM)
    - Sustainment Center of Excellence (SCoE)
- Army Materiel Systems Analysis Agency (AMSAA)

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EXECUTIVE SUMMARY

In 2010, the Army recognized the need to reduce sustainment demands at contingency bases. Contingency bases are highly dependent on resupply, which can be unpredictable, put Soldiers at risk in convoys, and impact mission completion. It is too costly and labor intensive for a small unit (platoon, company, battalion) to transport and maintain all required consumables (fuel and water) to last for weeks or months at small basecamps. In 2011, the US Army Office of the Assistant Secretary of the Army for Acquisition, Logistics, and Technology charged the Research Development and Engineering Command (RDECOM) with conducting a Technology Enabled Capability Demonstration (TECD) 4a - Sustainability/Logistics—Basing (SLB), now programmed as a Science & Technology Objective – Demonstration (STO-D) to develop, collaborate, and execute a program that would address these sustainment challenges.

> *The Army needs improved capability to enable sustainment independence by reducing resupply and backhaul demand at contingency basecamps. The FY12 through FY17 objective is to reduce the need for fuel resupply by 25%, reduce the need for water resupply by 75%, and decrease waste generation/backhaul by 50% while maintaining a Force Provider like Operational Quality of Life (QoL-(O)) at these basecamps.*

Current Army maneuver units have limited or no organic basing capability and rely on theater provided support. Except for Force Provider, the majority of theater provided equipment/support is not standardized, integrated, or optimized to be easily deployed, transported, or erected and is inherently inefficient. The problem mentioned above forms the basis for the program, lays the foundation for the formulation of the program execution plan, and is pervasively present in the program baseline.

The challenge is to formulate an integrated Model Based Systems Engineering approach for both technologies and non-materiel solutions to address current Army contingency basing barriers. The SLB-STO-D program uses modeling, simulation and analysis to show a reduction in fuel resupply by 25%, a reduction in water resupply by 75%, and a reduction of 50% in waste generated for backhaul at basecamps compared to an established technical and operational baseline, while maintaining a Force Provider-like QoL (O). The focus of the SLB-STO-D program is on the 50, 300, and1,000 personnel basecamps, on which the Army's Science and Technology (S&T) efforts are most likely to have a greater impact in resource reduction.

The technology demonstrations were managed by the Natick Soldier Research, Development and Engineering Center (NSRDEC) and conducted in a series of operationally relevant trials of 50, 300, and 1000 personnel capacity venues. These venues are located at the Base Camp Integration Laboratory (BCIL) at Fort Devens, MA and the Contingency Basing Integration and Technology Evaluation Center (CBITEC), Fort Leonard Wood, MO. The venues were selected for their ability to replicate operational environments in field contingency bases (e.g., billets, dining facilities, latrines, showers, etc.) and their unique instrumentation capabilities which support data acquisition to enable the conduct of subsequent analyses.

This technical report pertains to one physical demonstration that is part of the larger SLB-STO-D process: the events that transpired during the 50-Person Camp Demo at the BCIL, Fort Devens, MA venue during 29 September through 17 October 2014. It documents the objectives, technologies, methods, and results of the demonstration at the BCIL. In addition, this report contains information on two other data collection events for a tent liner conducted in March and July of 2014.

During this demonstration, four relevant technologies were showcased. These technologies were: Expedient Shelters with Non-woven Composite Insulation Liner (LINER); 1kWe JP-8 Fueled, Man-Portable GenSet (MANGEN); Renewable Energy for Distributed Under-supplied Command Environments (REDUCE); and Bidirectional Onboard Vehicle Power/Tactical Vehicle-to-Grid Module (OBVP/TV2GM). The LINER makes the billeting shelters more energy efficient, thus reducing the power required by Environmental Control Units (ECUs) to maintain internal temperatures. The MANGEN provides an operational energy capability in the 1kW range that is currently not available to deployed units. The REDUCE harvests solar energy to supplement a camp's power grid and thus reduce the amount of fuel required to operate generators. And the OBVP/TV2GM provides a mobile power source with distribution management required during the initial stages of establishing a basecamp.

The technologies were evaluated in the PdM FSS 300-person BCIL, which features Force Provider systems. Since the BCIL is designed and equipped as a 300-person camp, it afforded the opportunity to set up two 50-person camps for side-by-side comparisons. For this demonstration, a South Camp consisting of four billeting tents each powered by two 30 kW Tactical Quiet Generators (TQGs) was used as a baseline camp. A North Camp was set up with four billeting tents and powered by the OBVP/TV2GM and one 30 kW TQG. A Tactical Operations Center (TOC) was set up and powered by the REDUCE. In addition, MANGENs were employed in controlled demonstrations to power camp lights, a battery charger, and a load bank.

Data was collected in all systems using electronic instrumentation, automated data acquisition systems, and in some cases manual data collection methods (e.g., fuel consumption in TQGs). The data was monitored, harvested, processed, and securely stored in a network storage device by a Data Librarian, who was responsible for the accuracy and integrity of the data. Periodic data reviews were conducted by a Data Authentication Group to ensure the validity and fidelity of the data. After completion of the demonstration all data was provided to the Modeling, Simulation, and Analysis Team (MSAT), which is responsible for the application of pertinent modeling and simulation methods. The MSAT is also responsible for analyzing the data to garner results and draw conclusions pertaining to the efficacy of the technologies to meet water, fuel, and waste reductions. It is worth noting that in this particular demonstration, the technologies focused on fuel savings.

It is also worth noting that during the demonstration, Soldiers from the 542nd Quartermaster Company (Force Provider) participated in training sessions with each of the technologies and provided valuable input to the technology providers. Moreover, at the conclusion of the demonstration the Soldiers participated in a focus group session to provide input to Army researchers, who collected and documented their feedback. This is an important goal of the

demonstrations as SLB-STO-D searches for materiel and non-materiel solutions that reduce fuel, water, and waste in basecamps, while maintaining or improving the quality of life (QOL) of Soldiers. Soldiers' input in the areas of ease of set-up, maintenance, noise signature, priority of electrical loads, vulnerabilities, and potential operational use was recorded and made available to technology providers for future improvements. The Soldiers' input will be instrumental to meeting or exceeding the technical and QOL goals of the SLB-STO-D program.

During the 50-Person Camp Demo at the BCIL, the SLB-STO-D team was able to achieve the main objective of Demonstration #1, which was to collect empirical data on candidate and baseline technologies to calibrate modeling and simulation models, and to conduct subsequent analysis. This objective was achieved and the datasets were delivered.

Other notable accomplishments were:

- Power data collected and authenticated in March showed reduced energy consumption for heating billeting shelters to be around 35% with the new LINER. This data set was used to calibrate part of the fuel, water, and waste model and the new liner was then "virtually demonstrated" in three different climate zones, while integrated into a representative basecamp system. Comparing fuel use of the baseline camp (using the old liner) and the same camp with the new LINER showed an overall fuel consumption savings of 5% on average, a significant portion of the SLB-STO-D goal of 25% fuel savings.
- The MANGEN demonstrated that it can burn JP-8 and produce electrical power. The Soldiers found that the generators are easy to use and are easily portable. Soldiers had many positive comments and suggested the MANGENs should be employed for duty in locations such as guard towers and motorpools.
- The REDUCE demonstrated that the trailer-mounted hybrid electrical system can harness solar energy and produce electrical power distributed through extension cords. Soldiers found that the system was easy to install and straightforward to operate. The Soldiers liked the quiet operation of the REDUCE when power was supplied from the battery.
- The OBVP/TV2GM successfully demonstrated an initial entry capability to provide, manage, and distribute power to a basecamp early in its construction. The Soldiers found great benefit with this mobile power-production capability. As for fuel savings, more work is required to identify the proper low and high priority loads for switching power on and off while maintaining critical camp functions.
- Shortening of the developmental cycle of the technologies can be facilitated through lessons learned from integration and interoperability with other systems. For example, the power system that was demonstrated at the 50-person demo garnered the understanding that the power spikes during start-up of the ECUs were unmanageable with the current software/hardware configuration. This provided advance technical insight into a reconfiguration of the system to overcome this problem.

By all measures, this initial demonstration was a success. This integrated demonstration event saved Army resources. Venue coordination, logistics, integration with other systems and technologies, stakeholder engagements, data collection and authentication are done collectively, rather than requiring each individual project officer to organize and execute their own

demonstration event. The demonstration allowed the Army Research, Development, and Engineering Centers (RDECs) to encounter the challenges of integration in a “field” environment and to expose their technologies to Soldiers, who provided valuable feedback to improve their technologies. This created a “Win-Win” situation that can shorten the development and maturation cycles of the demonstrated technologies. The SLB-STO-D, and specifically the Experimentation, Demonstration, and Validation Team (EDVT), learned a number of lessons during planning, preparation, and execution that will improve future demonstrations. The SLB-STO-D’s data management processes were key to the success of this demo. These processes will continue to improve with experience as all functional teams dedicate the right manpower and resources early in the demonstration planning phase to identify and track the required data elements.

SUSTAINABILITY LOGISTICS BASING - SCIENCE AND TECHNOLOGY OBJECTIVE - DEMONSTRATION

DEMONSTRATION #1
50-PERSON CAMP DEMO

1. INTRODUCTION

This technical report documents the objectives, candidate technologies demonstrated, methods used, and results of the Demonstration #1 conducted by the Sustainability Logistics Basing – Science and Technology Objective – Demonstration (SLB-STO-D) during the period 29 September – 17 October 2014 at the Base Camp Integration Laboratory (BCIL), Fort Devens, MA. This report does not include analysis of the data collected. The analysis was a separate effort that followed the demonstration, and will be documented in a separate report.

The work was performed in collaboration with:

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    - Communications-Electronics Research, Development and Engineering Center (CERDEC)
    - Tank and Automotive Research, Development and Engineering Center (TARDEC)
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    - Maneuver Support Center of Excellence (MSCoE)
    - Combined Arms Support Center (CASCOM)
    - Sustainment Center of Excellence (SCoE)
- Army Materiel Systems Analysis Agency (AMSAA)

1.1 The SLB-STO-D Program

In 2010, the Army recognized the need to reduce sustainment demands at contingency bases. Contingency bases are highly dependent on resupply, which can be unpredictable, put Soldiers at risk in convoys, and impact mission completion. It is too costly and labor intensive for a small unit (platoon, company, and battalion) to transport and maintain all required consumables (fuel and water) to last for weeks or months at small basecamps. In 2011, the US Army Office of the Assistant Secretary of the Army for Acquisition, Logistics, and Technology charged the Research Development and Engineering Command (RDECOM) with conducting a Technology Enabled Capability Demonstration (TECD) 4a - Sustainability/Logistics—Basing (SLB), now programmed as a Science & Technology Objective – Demonstration (STO-D) to develop, collaborate, and execute a program that would address these sustainment challenges.

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Current Army maneuver units have limited or no organic basing capability and rely on theater provided support. Except for Force Provider, the majority of theater-provided equipment/support is not standardized, integrated, or optimized to be easily deployed, transported, or erected and is inherently inefficient. The above-mentioned problem statement forms the basis for the program, lays the foundation for the formulation of the program execution plan, and is pervasively present in the program baseline.

The challenge is to formulate an integrated Model Based Systems Engineering (MBSE) approach for both technologies and non-materiel solutions to address current Army contingency basing barriers. The SLB-STO-D program uses modeling, simulation and analysis to show a reduction in fuel resupply by 25%, a reduction in water resupply by 75%, and a reduction of 50% in waste generated for backhaul at basecamps compared to an established technical and operational baseline, while maintaining a Force Provider-like QoL (O). The focus of the SLB-STO-D program is on the 50, 300, and 1,000 personnel basecamps, on which the Army's Science and Technology (S&T) efforts are most likely to have a greater impact in resource reduction

1.2 Overall Demonstration Concept and History

This section presents the general concept for the demonstrations to be conducted as part of the SLB-STO-D project. The "who", "when", "what", and "where" are included. The "why" is covered in Section 1.3 Demonstration Purpose.

Who: The SLB-STO-D has six functional teams supporting the demonstration concept. The demonstration is led by the Experimentation, Demonstration, and Validation Team (EDVT), and is supported by the other functional teams — Technology Maturation and Integration Team (TMIT), Systems Engineering and Integration Team (SEIT), Modeling, Simulation, and Analysis Team (MSAT), Requirements Integration Team (RIT), and the Core Leadership Team (CLT). Each functional team had a role to play. Also, each Technology Provider for the various

candidate technologies, and their supporting contractor or vendor if applicable, participated in the demonstrations. Moreover, for each of the demonstrations there was some level of participation by Soldiers from various units.

When: The demonstrations are managed by fiscal year. Demonstration #1 was executed in FY15 and Demonstration #2 was executed in FY16. The full scope, including the planning window of each demonstration, included four phases – Planning Phase, Demonstration Preparation Phase, Integrated Demonstration Phase, and Analysis & Reporting Phase. The Planning phase began with the development of the first Demonstration and Assessment Master Plan (DAMP) (Harris, 2013). The Demonstration Preparation Phases for Demonstration #1 began in April 2014 and featured testing of individual technologies by the sponsoring technology developers.

What and Where: The Integrated Demonstration Phase for Demonstration #1 began with the execution of the 50-person basecamp demonstration during the period from 29 September–17 October 2014 at the BCIL at Fort Devens, MA. Technologies demonstrated at the BCIL included:

- Expedient Shelters with Non-woven Composite Insulation Liner (LINER)
- 1kWe JP-8 Fueled, Man-Portable GenSet (MANGEN)
- Renewable Energy for Distributed Under-supplied Command Environments (REDUCE)
- Bidirectional Onboard Vehicle Power/Tactical Vehicle-to-Grid Module (OBVP/TV2GM).

This report describes in detail the objectives, demonstrated technologies, methods, and results of this demonstration.

1.3 Demonstration Purpose

There is neither sufficient time nor resources for the SLB-STO-D to demonstrate all variations of technologies and current basecamp systems in multiple environments and multiple configurations. Therefore, a MBSE approach is key to meet the program goals. In support of the MBSE approach, the key purpose of this demonstration was to collect empirical data on selected candidate technologies and the BCIL's 300-person camp baseline systems in an operationally relevant environment. Data will be used as indicated in the Analytical Framework below **(Figure 1)** and described in the SLB-STO-D Systems Engineering Plan. Many iterations of various basecamps can be virtually simulated to assess accomplishment of the SLB-STO-D fuel, water, and waste challenge.

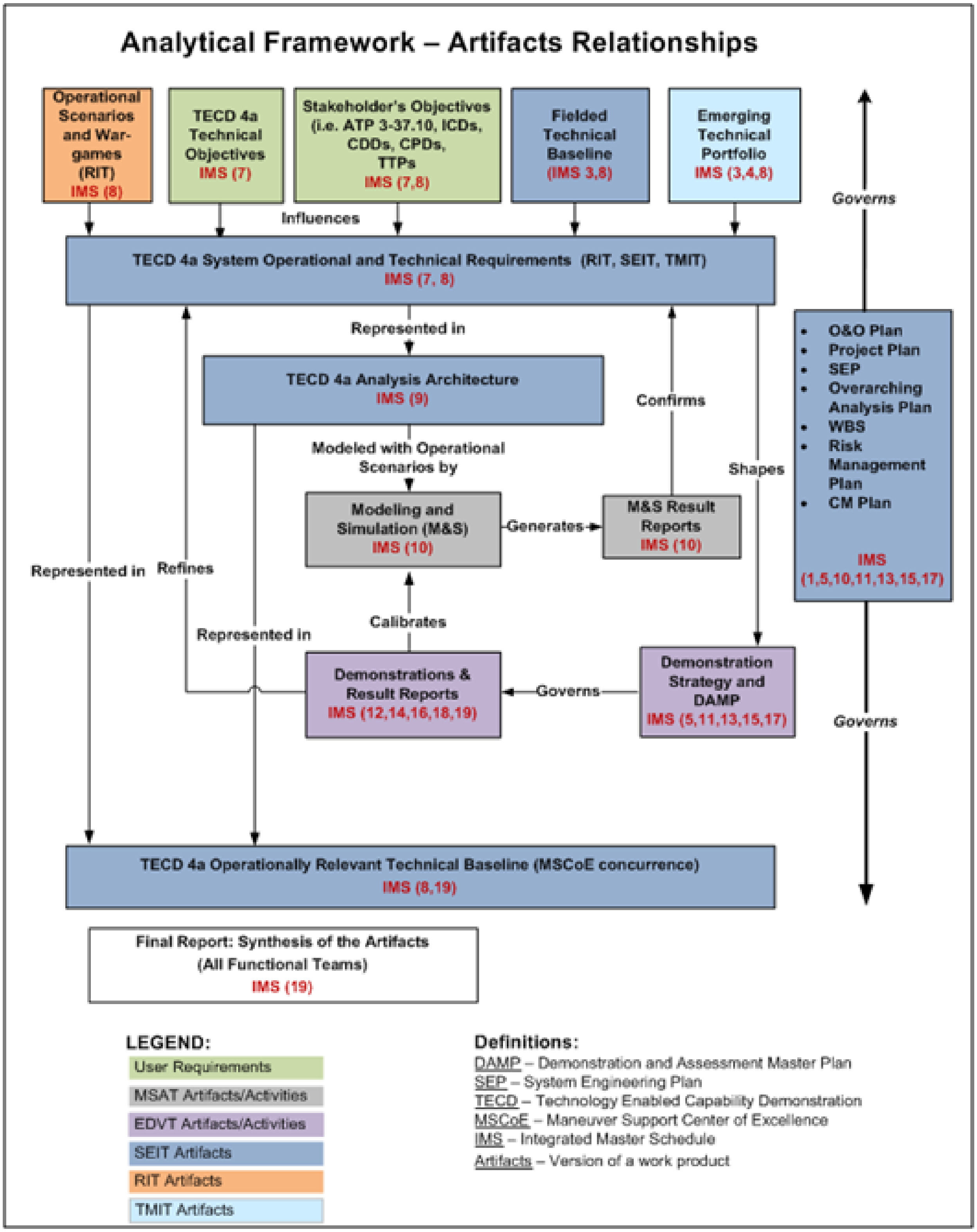

Figure 1: Analytical Framework

1.4 Integrated Demonstration Phase Objectives

The specific objectives for each of the Integrated Demonstration Phases are directed by the CLT in the Demonstration Strategy Document. These objectives are:

- **Objective 1**: Collect empirical data on candidate technologies and baseline systems that can be used to calibrate modeling, simulation, and analysis, and support trade-offs and engineering decisions (main effort).
- **Objective 2**: Collect data on non-materiel solutions that can be used to influence the operational baseline, including doctrine, organization, training, leadership, personnel, and facilities.
- **Objective 3**: Collect data on Quality of Life at the camp.
- **Objective 4**: Show how SLB-STO-D meets Contingency Basing (CB) and Operational Energy (OE) gaps.
- **Objective 5**: Showcase any "Wow Factors," i.e., the materiel and non-materiel game changers.
- **Objective 6:** Present modeling and simulation methods and results as part of the demonstration through visual and physical displays, such as posters and computer representations of models.

1.5 Demonstration #1 Overview

Demonstration #1 began in April 2014. The demonstration was divided into three phases—the Demo Prep Phase, the Integrated Demo Phase, and the Analysis and Reporting Phase. The Integrated Demo Phase was further subdivided based on camp size. Demonstrations were performed for the 50-person camp, the 300-person camp, and the 1000-person camp (**Error! Reference source not found.**).

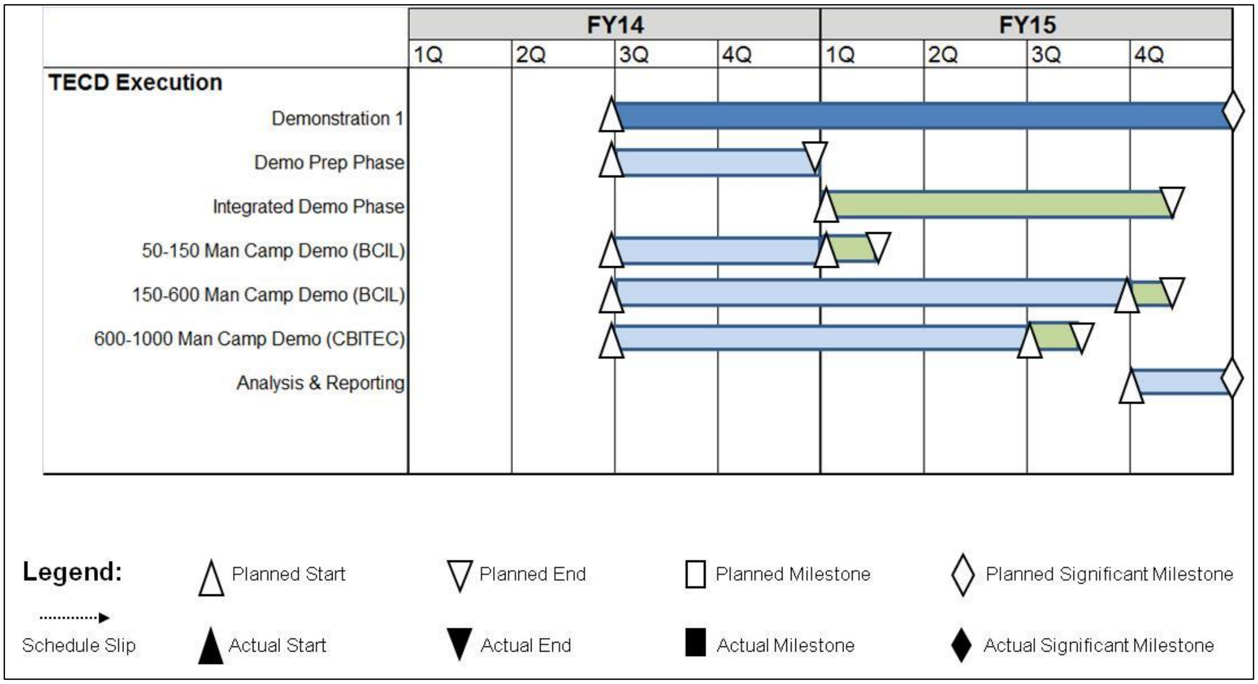

Figure 2: Demonstration #1 Phases

The Demo Prep Phase began in April 2014 and is the responsibility of the project office for each of the selected candidate technologies. The Integrated Demo Phase for the 50-person camp demonstration took place in October 2014 at the BCIL at Fort Devens, MA. This document primarily focuses on the Integrated Demo Phase for the 50-person camp demonstration at the BCIL.

The technologies were originally proposed by the TMIT for inclusion in the SLB-STO-D. Five of the SLB-STO-D candidate technologies were selected for participation in the 50-person camp demonstration. These are listed below in **Table 1**. Then, a panel of all the functional teams selected the technologies for this demonstration based on relevance to camp size, availability, and projected maturity. The numeral in the first column in the table is an administrative designation. Each candidate technology in Demonstration #1 was assigned a number in sequence. The value of the numeral has no quantitative meaning.

Table 1: Selected Technologies for 50-Person Camp Demonstration

#	Title	Short Title	Org	POC	TRL	Ready	Camp Size			Focus Area
							50-150	150-600	600-1K	
3	Expedient Shelters w/ Non-woven Composite Insulation Liners	LINER	NSRDEC	Swisher	7	1Q13	X	X	X	Fuel
7	1kWe JP-8 Fueled, Man-Portable GenSet	MANGEN	CERDEC	Nawrocki	8	2Q14	X	?		Fuel
8	Single Common Power train Lubricant	SCPL	TARDEC	Comfort	7	4Q13	X	X	X	Fuel
9	Renewable Energy for Distributed Under-supplied Command Environments	REDUCE	CERDEC	Teicher	5/6	2Q13	X	?		Fuel
18	Bidirectional Onboard Vehicle Power	OBVP	TARDEC	Troung	6/7	1Q13	X	?		Fuel

The Single Common Powertrain Lubricant (SCPL) was selected for Demonstration #1 but was not demonstrated at the BCIL in October. Further coordination with PME2S2) was required to

collect data on fuel savings associated with using SCPL in basecamp generators. Data was collected and available for the SLB-STO-D after the third quarter Fiscal Year 2016.

A select group of seven Soldiers from the 542nd Quartermaster Company (Force Provider) participated in the demonstration. Each technology provider trained each of the Soldiers on their technology for a day according to a round-robin schedule. At the conclusion of the demonstration the Soldiers participated in a focus group during which data was collected and Soldier feedback documented.

2. DEMONSTRATED TECHNOLOGIES

The systems employed during the demonstration can be categorized in two ways—as candidate technologies (i.e., technologies in S&T that are not yet fielded) and as baseline technologies (i.e., mature technologies that have been fielded). The candidate technologies were selected by the TMIT for inclusion in the demonstration based on an entrance criteria and selection process.

Data were collected on key baseline technologies to be used in modeling/simulation efforts for comparison to determine savings in fuel, water, and waste. Furthermore, baseline technology data were used to calibrate the modeling and simulation computer models to enhance their fidelity.

The candidate technologies that were selected for this demonstration are described in the following sections.

2.1 Expedient Shelters with Non-woven Composite Insulation Liners (LINER)

All billeting tents in the BCIL currently have this new and improved LINER installed (shown in Figure 3). This version is made by the Camel Manufacturing Company. The following text is from Camel's website

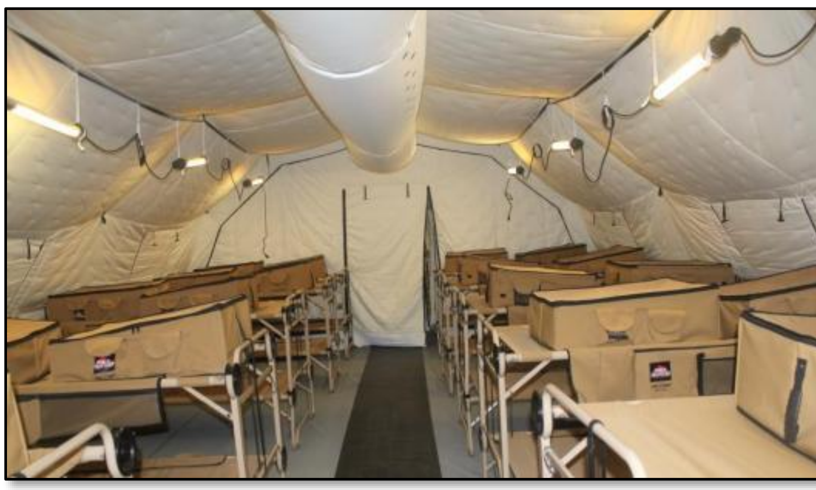

Figure 3: Extreme Weather Liner.

> "The Camel Extreme Weather Liner has been successfully designed and developed into multiple components for ease of set up, strike and packing. The insulated liner is fabricated from 3M™ Thinsulate™ FR-SH 250 gram Insulation, providing an Effective R-value of over 7.2. Our (Insulated) Liners are designed to assist field heaters and air conditioners at maintaining specific temperature ranges inside the shelter during operational use. Design considerations took into account the intent to limit lost air through openings and unprotected areas. Accordingly, liners were designed to overlap and fill vacancies and openings that can enable temperature loss. These liners provide upgrades from single ply liners that provide enhanced environment protection to the Command and Control (C2) equipment utilized in the Tactical Operations Center (TOCs) during extreme environmental conditions."
> http://www.camelmfg.com/products-ewl.php:

2.2 Man-Portable GenSet, 1kWe JP-8 Fueled (MANGEN)

The MANGEN uses electronic controls to enable load following and a fuel processor designed to enable the use of a commercial-off-the-shelf gasoline engine with logistics fuels, thereby allowing the realization of a highly power dense, JP-8 fuel compatible power system. This design allows the Army to address techniques to reduce fuel consumption, expand operational flexibility through use of logistics fuels and gasoline, and extend the power spectrum by filling the power gap between available batteries and the smallest fueled DoD power generator of 2000 watts. The project office delivered seven units: four beta units from Precision Combustion Inc. (PCI); two units from Novatio; and one unit from QinetiQ. The requirements specify the systems be designed to output 700–900 W, 120 VAC, 28 VDC 1.0 PF, 60 Hz and operate at temperatures between -25 ºF and 140 ºF.

Figure 4 shows the three MANGEN models.

Figure 4: Man-Portable Generators (left to right) – QinetiQ, PCI, and Novatio

For ease of data collection, both the PCI and Novatio models operated from external fuel tanks (not shown in the photo).

2.3 Renewable Energy for Distributed Under-supplied Command Environments (REDUCE)

The REDUCE trailer can provide up to 3-4 kW of 240 VAC power or 3-4 kW of 120 VAC power through each of its two legs using only renewable energy sources: solar panels, two wind turbines, JP8/diesel genset, and alternating current (AC) shore power. The system can be towed by a High Mobility Multipurpose Wheeled Vehicle (HMMWV). The trailer system is a hybrid renewable energy system consisting of 2 kW worth of non-glass encapsulated silicon solar panels and 6-12 kWh of lead acid batteries that are mounted on a Light Tactical Flatdeck Trailer (LTT-F). The REDUCE can store up to 6-12 kWh of energy.

The project office shipped two REDUCE units to the demonstration, one with wind turbines and one without. For the demonstration, the team operated and collected data from the system without wind turbines due to the greater reliability of its integrated genset. The system with wind turbines was erected as a static display only. **Figure 5** is the REDUCE with the solar panels deployed.

Figure 5: REDUCE

2.4 Bidirectional Onboard Vehicle Power/Tactical Vehicle-to-Grid Module (OBVP/TV2GM)

The OBVP/TV2GM provides power generated from a HMMWV and an intelligent distribution of available power based on electrical load demands and priorities set by users. OBVP and TV2GM technologies are not intended to replace Tactical Quiet Generators (TQGs), but to close a capability gap currently affecting forward-deployed forces by adding the ability to provide AC power to Forward Operating Bases long before logistical (i.e., TQG) support can arrive. As TQGs arrive and are integrated into the micro-grid, OBVP-equipped vehicles can be moved to other areas as needed. The OBVP/TV2GM system can manage a load total in excess of its generating capacity by time-slicing non-critical (low-priority) loads. For this demonstration, the OBVP was paired with a 30kW TQG. Figure 6 shows the OBVP/TV2GM – right-front view, rear view, and cab interior.

Figure 6: Bidirectional Onboard Vehicle Power/Tactical Vehicle-to-Grid Module

3. BASELINE SYSTEMS, ARCHITECTURE, AND INSTRUMENTATION

To address the SLB-STO-D challenge of saving fuel, water, and waste the candidate systems described above must be integrated with the basecamp infrastructure and then instrumented to collect data. This chapter accomplishes the following: (a) identifies the basecamp infrastructure at the BCIL, (b) documents the architecture showing how the candidate technologies are integrated with that infrastructure, and (c) identifies the instrumentation that will be installed to collect the data.

3.1 Baseline and Other Demonstration Support Systems

As previously noted, this demonstration took place at the BCIL. The BCIL is mostly composed of two 150-person Force Provider Expeditionary (FPE) camp sets. For the purposes of this demonstration, the FPE systems are considered "baseline systems" and comprise the bulk of the systems in the SLB-STO-D's approved Operationally Relevant Technical Baseline (ORTB). Figure 7 is an aerial view of the BCIL taken in 2014. The tan-colored systems in the photo are the FPE camp sets. The green-colored systems, while no longer in place, are a fair representation of the Energy Efficient Rigid Wall Shelters (E2RWS) modules that were in place during this demonstration.

Figure 7: BCIL Aerial View (circa 2014)

The Army maintains FPE capabilities in order to provide critical basecamp life support to the U.S. Army, even as it transforms from a legacy to a modular to a future Force. The FPE system is essentially a "tent city" that is (1) containerized and highly deployable via all means of transport (air, land, sea); (2) employable upon arrival in as little as 24 hours without significant dependencies on local infrastructure; (3) capable of reliable and efficient systems operations and management; and (4) outfitted with the intent to provide improved life support sustainment, combat readiness, and quality of life for deployed Soldiers, regardless of location. An FPE module is designed to support 150 personnel. Each FPE module provides climate-controlled billeting, quality food preparation and dining facilities, and hygiene services (latrine, shower, laundry) through a blend of commercial and military equipment. Waste management (solid waste, and grey and black water/sewerage), fuel and water storage and distribution, and power generation (generators, and prime power connection kits) are also included in FPE modules.

The basecamp systems that were employed during the demonstration can be categorized in two ways. The first category includes the key baseline systems that must be considered and characterized to enable the MSAT to make technical comparisons to determine savings in fuel, water, and waste. The second category is the SLB-STO-D candidate technologies selected by the TMIT for inclusion in the demonstration. The SEIT carefully considered the proper integration for each of the candidate technologies and developed system views. The EDVT layered on top of these systems and corresponding architectures the appropriate instrumentation to collect data.

The demonstration employed a number of BCIL baseline systems, including the billeting shelters and TQGs. The demonstration employed a number of systems that are not part of the SLB-STO-D baseline but are surrogates employed to execute the demo. These systems included the Improved Environmental Control Unit (IECU) and the Tactical Operations Center (TOC) shelter.

3.1.1 Tent, Extendable, Modular, Personnel (TEMPER) Air Supported Shelter

The BCIL contains 16 32-foot TEMPER Air Supported shelters for billeting. This demonstration employed eight of these shelters.

The Air Supported shelter floor space is 20 x 32 feet. There are four identical 10-inch diameter 20-foot clear-span supports. The interior of each billeting tent contains 11 sets of bunk beds, 2 rows of overhead lights, 2 electrical wiring harnesses, and an air distribution plenum. Each of the billeting tents was shaded with the Ultra-Lightweight Camouflage Net System (ULCANS). **Figure 8** is an external view of the billeting tents with ULCANS in the North Camp of the BCIL.

The billeting shelters also included one of the technologies selected for this demonstration, the Non-woven Composite Insulation Liner described in Section 2.1.

Figure 8: Air Supported Shelter (external view)

3.1.2 MEP-805B, Generator Set, Diesel Fueled, Tactical Quiet, 30 kW

The TQG, 30kW, provides mobile electric power of 120/208 VAC and 240/416 VAC, single-phase and/or three-phase connections. It is capable of utility operations of 50/60 Hz. The generator set is easily transported, operated, and maintained. It is a fully enclosed, self-contained, skid mounted, portable unit. It is equipped with controls, instruments, and accessories necessary for operation as a single unit or in parallel with another unit of the same class and mode. The generator set consists of a diesel engine, brushless generator, cooling system, excitation system, speed-governing system, fuel system, 24VDC starting system, Digital Control System (DCS), and fault system.

The demonstration employed three units. Two TQGs were set up to power four tents in the South Camp (**Figure 9**) as per the TECD 50-person camp baseline and one TQG was integrated with the OBVP/TV2GM system in the North Camp (**Figure 10).**

Figure 9: TQGs Powering South Camp

Figure 10: TQG with OBVP/TV2GM

3.1.3 Hardwall Shelter, TOC

The SLB-STO-D 50-person camp baseline calls for a hardened shelter, presumably a wood frame structure to be used for a Command Post (CP). There is no such wooden structure at the BCIL. Instead, the BCIL has a hardwall shelter in the center of the camp that units use as their TOC (**Figure 11**). The demonstration team used this structure as the TECD Operations Center for the duration of the demo.

Figure 11: TOC Shelter in the BCIL

The interior of the TOC, prior to the demo, is shown in the photos in **Figure 12**.

Figure 12: TOC Interior

The hardwall shelter was outfitted with various computers and other powered systems to simulate the power draw of an operational CP. **Figure 13** shows typical daily operations in the TOC.

Figure 13: TECD Operations Center

3.1.4 IECU

The Force Provider billeting tents are routinely heated (and cooled) with the F100-60K Environmental Control Unit (ECU). Each billeting tent has a dedicated ECU mounted on a platform to the left of the entrance vestibule. The SLB-STO-D approved FY12 baseline includes F100 ECUs. However, for this demonstration—to accommodate the power management prioritization capability of the TV2GM—the F100 units were replaced with the IECU due to their soft start capability, allowing them to be powered (ON/OFF) remotely by direction from the TV2GM. All ECUs are normally powered from commercial utility power through the camp’s electrical grid. However, for this demonstration, the IECUs were powered by either the baseline 30kW TQG in the South Camp or the OBVP/TV2GM in the North Camp. The IECU operating modes are OFF/COOL/HEAT/VENT. Internal shelter temperature was roughly controlled with a manually adjustable potentiometer. **Figure 14** shows the IECU.

Figure 14: IECU, Ductwork, and Potentiometer

3.2 Architecture

The systems on the BCIL's master layout (**Figure 15**) are integrated with a system of systems approach. The system of systems approach provides the foundation to form the camp's architecture. The BCIL's two 150 man mirror image camp allowed the team the opportunity to establish a side-by-side comparison of two 50-person camps.

The BCIL is divided into two roughly equal camps – the North Camp (top half of the figure) and the South Camp (bottom half of the figure). Each camp contains eight billeting tents, a kitchen, a dining facility, two showers, two latrines, and a laundry unit. In addition, central to the camp, there is a hardwall shelter that generally serves as the resident unit's CP or TOC. There is also a Lightweight Maintenance Enclosure in the camp that units often use to house training.

For this demonstration, four billeting tents in the South Camp were used as baseline controls. They were each powered by two 30 kW TQGs. Four billeting tents in the North Camp employed the TECD technologies of interest, chiefly the OBVP/TV2GM, plus one 30kW TQG. Systems in the TOC were powered by the REDUCE. There was no independent baseline control for the TOC. MANGENs were employed in more technical, controlled demonstrations to power camp lights, a battery charger, and a load bank.

The east side of camp was not part of the usual 300-person footprint. Currently, there are a number of new hardwall shelters (grayed out in the figure) that have been erected in multi-level billeting units. These structures were not part of the demonstration.

The SEIT developed architecture views for each of the candidate technologies, except the LINER, to describe how they were integrated into the 50-person camp for the demonstration. Systems views (SV-2s) for each technology follow. These diagrams are taken from the document SEIT_Plan_Integration-50PAX_Robust_v2-0_D.

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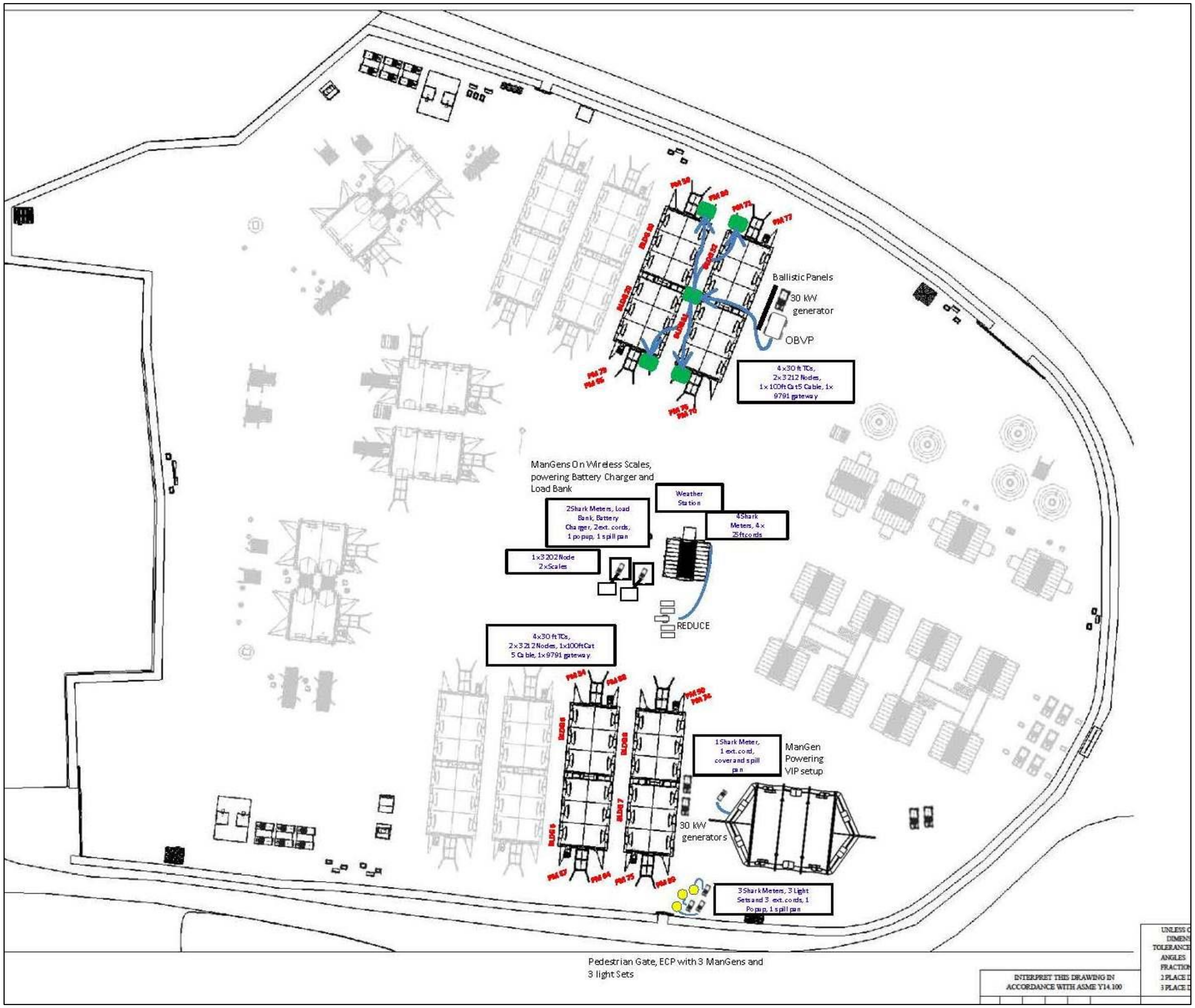

Figure 15: BCIL Master Layout

3.2.1 LINER Architecture

The LINERs are already a part of the BCIL’s operational baseline. Each Air Supported shelter used for billeting has the LINER installed. No distinct architecture or system view was developed for the LINER.

3.2.2 MANGEN Architecture

Figure 16 shows the SV-2 for the MANGEN technology.

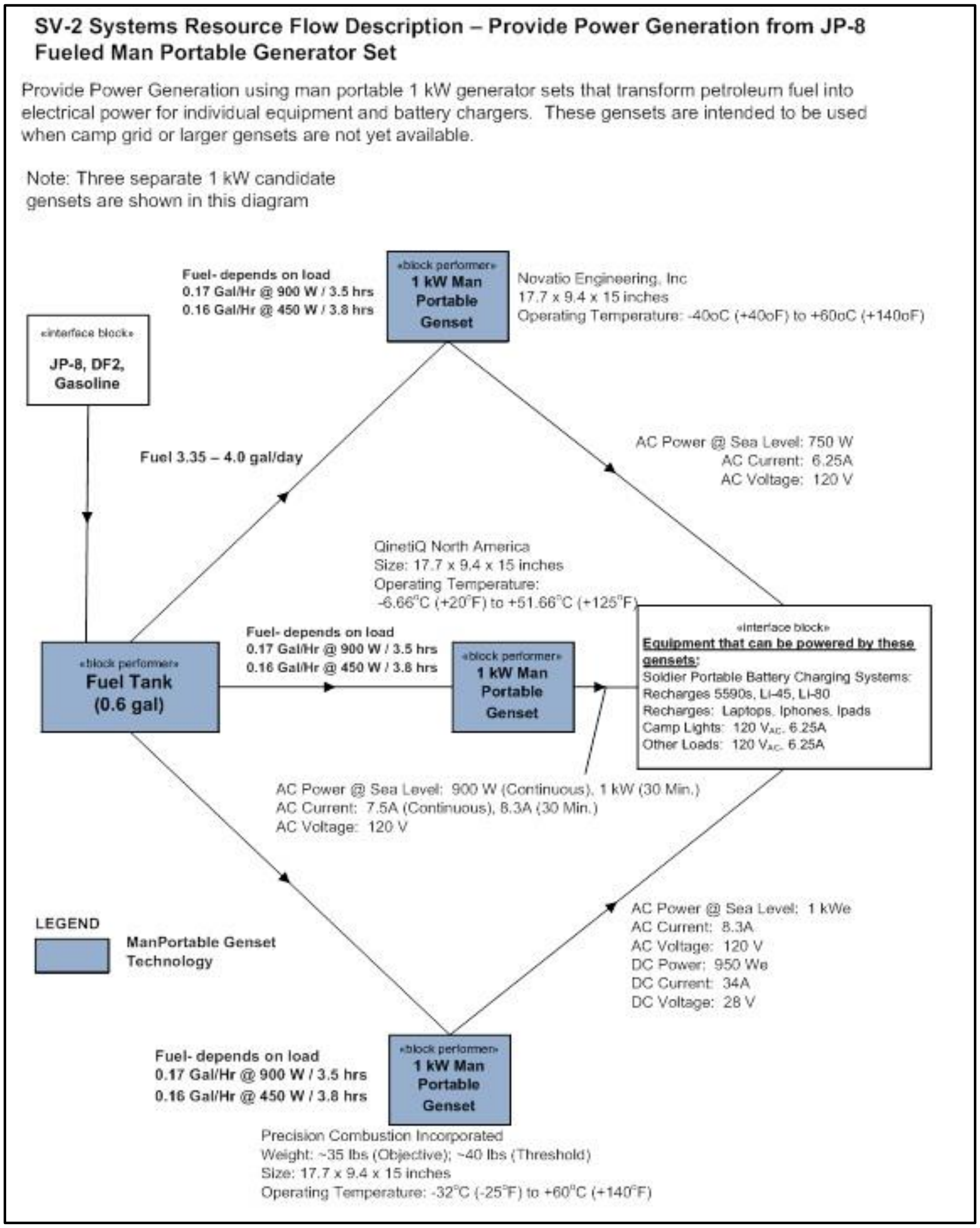

Figure 16: MANGEN SV-2

3.2.3 REDUCE Architecture

Figure 17 shows the SV-2 for the REDUCE technology.

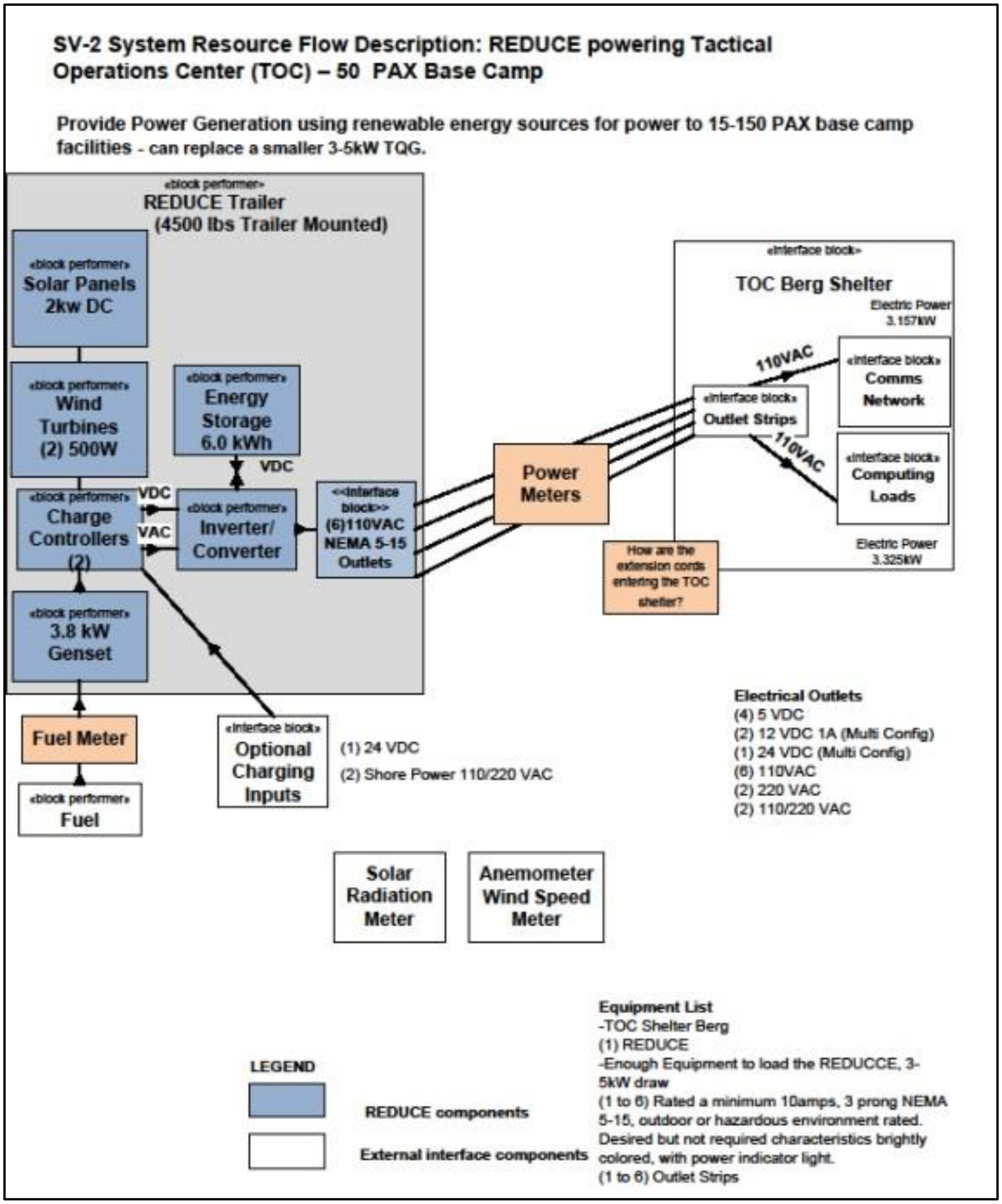

Figure 17: REDUCE SV-2

3.2.4 OBVP/TV2GM Architecture

In support of the OBVP/TV2GM, the SEIT developed two system views – one for the baseline in the South Camp (**Figure 18**) and one for the OBVP/TV2GM in the North Camp (**Figure 19**).

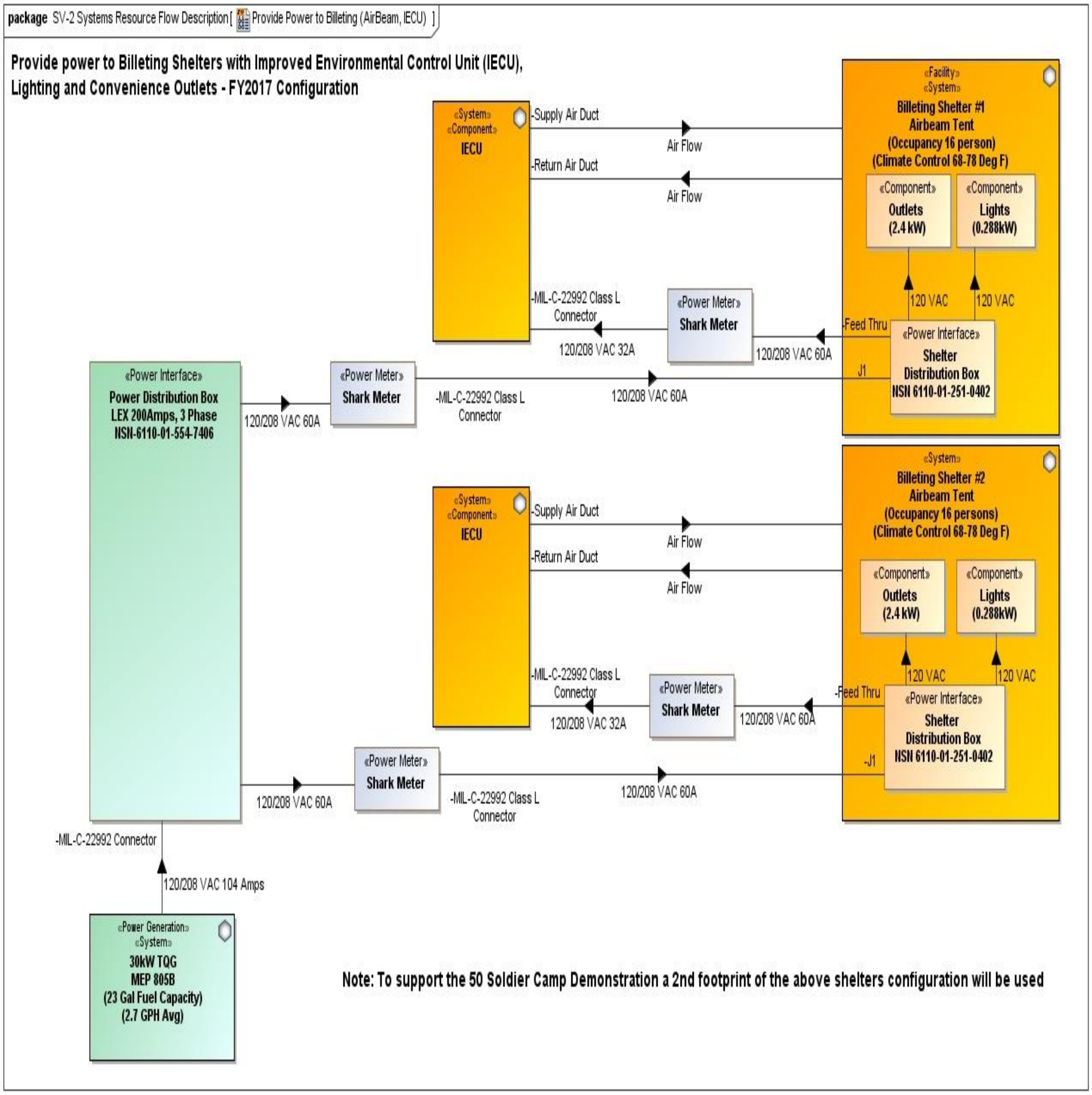

Figure 18: Baseline SV-2

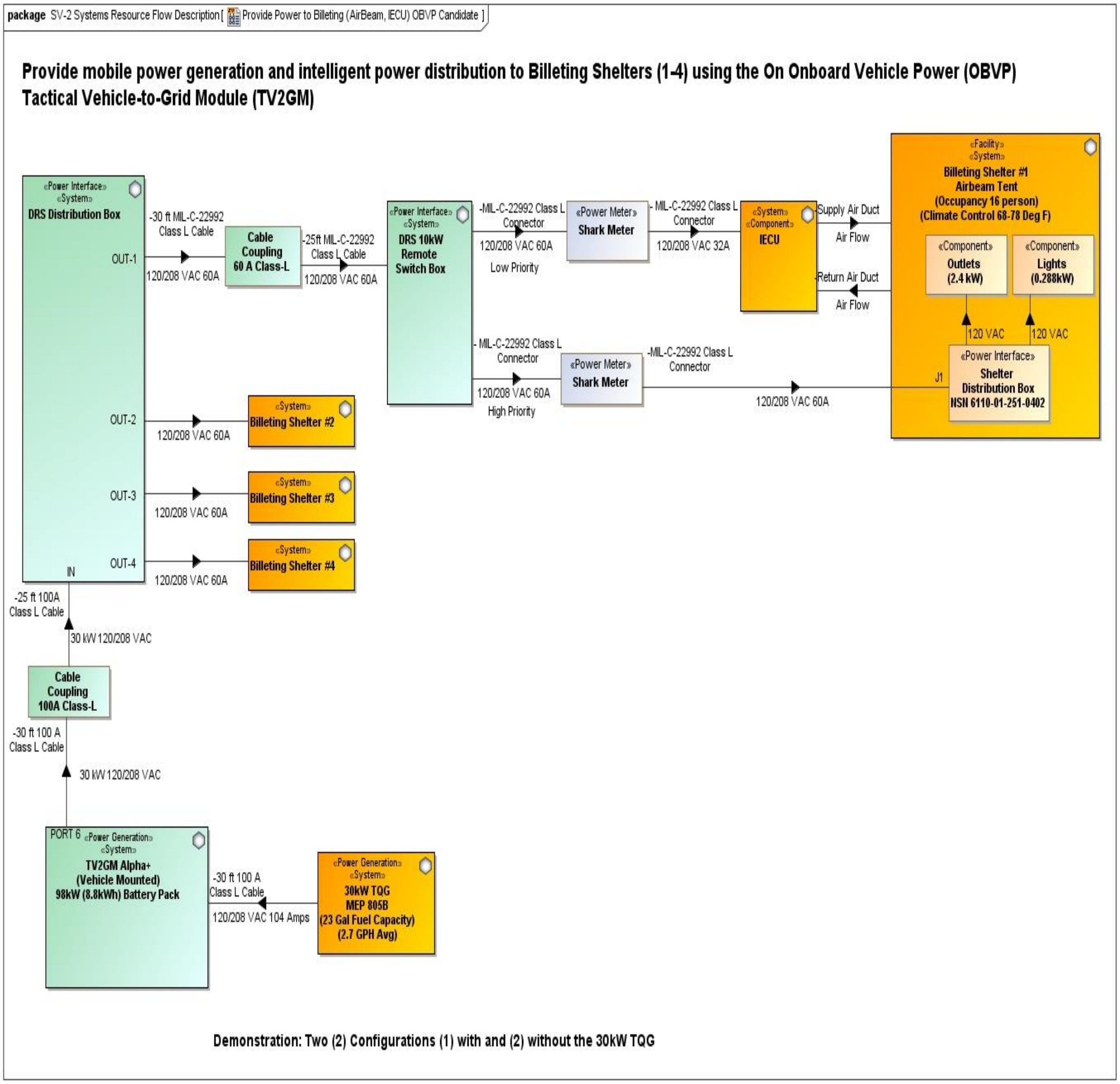

Figure 19: OBVP/TV2GM SV-2

3.3 Instrumentation

To meet **Objective 1** (Collect empirical data on candidate technologies and baseline systems that can be used to calibrate modeling, simulation, and analysis, and support trade-offs and engineering decisions) the following instrumentation was employed.

3.3.1 Power Meters

The BCIL is instrumented with a number of existing power meters that collect power data on various structures and camp components, including the billeting tents in the North and South Camps that are part of this 50-person camp demo. The EDVT procured a number of new 20-amp

power meters to collect power data on loads for the REDUCE and the MANGEN technologies. An example of a Shark power meter is shown in **Figure 20**.

Figure 20: Shark® 200 Power Meter

From their website at http://www.electroind.com/shark200-data-logging-power-meter.html#nogo, the Shark® 200 Data Logging Power Meter/Transducer features include:

- 0.2% Class Revenue Certifiable Energy and Demand Metering
- Expandable I/O with 100BaseT Ethernet
- V-Switch™ Key Technology Upgrade
- Extensive Data Logging
- Power Quality Recording
- Embedded Web Server - With Smartphone and Tablet Support
- New DNP 3.0 over Ethernet

The BCIL maintains a spreadsheet of the power meter locations and their IP addresses. The table is too large to present here in this document, so therefore the file is maintained on the SLB-STO-D SharePoint. Most billeting tents in the BCIL have two power meters, (a) one that collects total power draw including the ECU, lighting, and convenience power, and (b) one that collects only the ECU power draw.

Data from the power meters is transmitted over a wireless and local area network. Through the use of National Instruments LabView software, the power meters are queried and data is pulled through the BCIL's network to their server. This power data is time-stamped based on when the central line bus queries the Shark meters, which leads to asynchronous data collection. The bus queries the meters, but if they do not respond within a proper time window, the timestamp can vary by as much as 20% of the base query timing of 1 minute.

A diagram of the Shark meter kit with enclosure is shown below (**Figure 21**) to depict how they are connected.

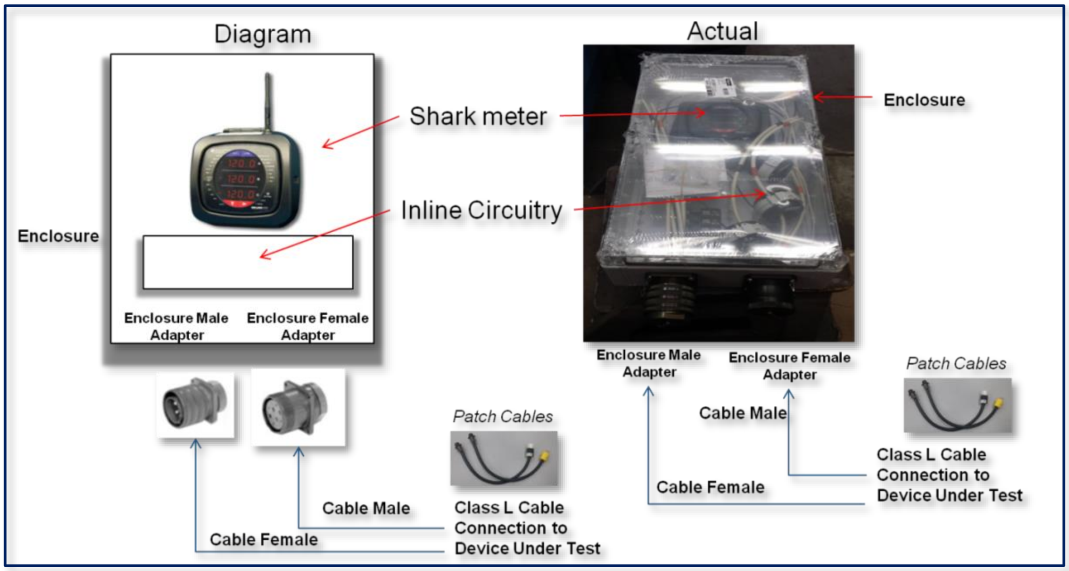

Figure 21: Shark Meter Kit

Shark Meters integrated with the MANGEN: **Figure 22** shows a typical set-up with a Shark meter integrated with a MANGEN during data collection.

Figure 22: Shark Meter Integrated with MANGEN

Shark Meters integrated with the REDUCE: **Figure 23** shows four Shark meters integrated with the REDUCE trailer. The Shark meters are attached directly to the power outlets on the REDUCE. The “power out” cables from the Shark are attached to four extension cords that run into the TOC.

Figure 23: Shark Meters Integrated with REDUCE

Shark Meters integrated with the billeting tents powered by the OBVP/TV2GM in the North Camp: **Figure 24** shows the typical Shark meter set up in the North Camp tents.

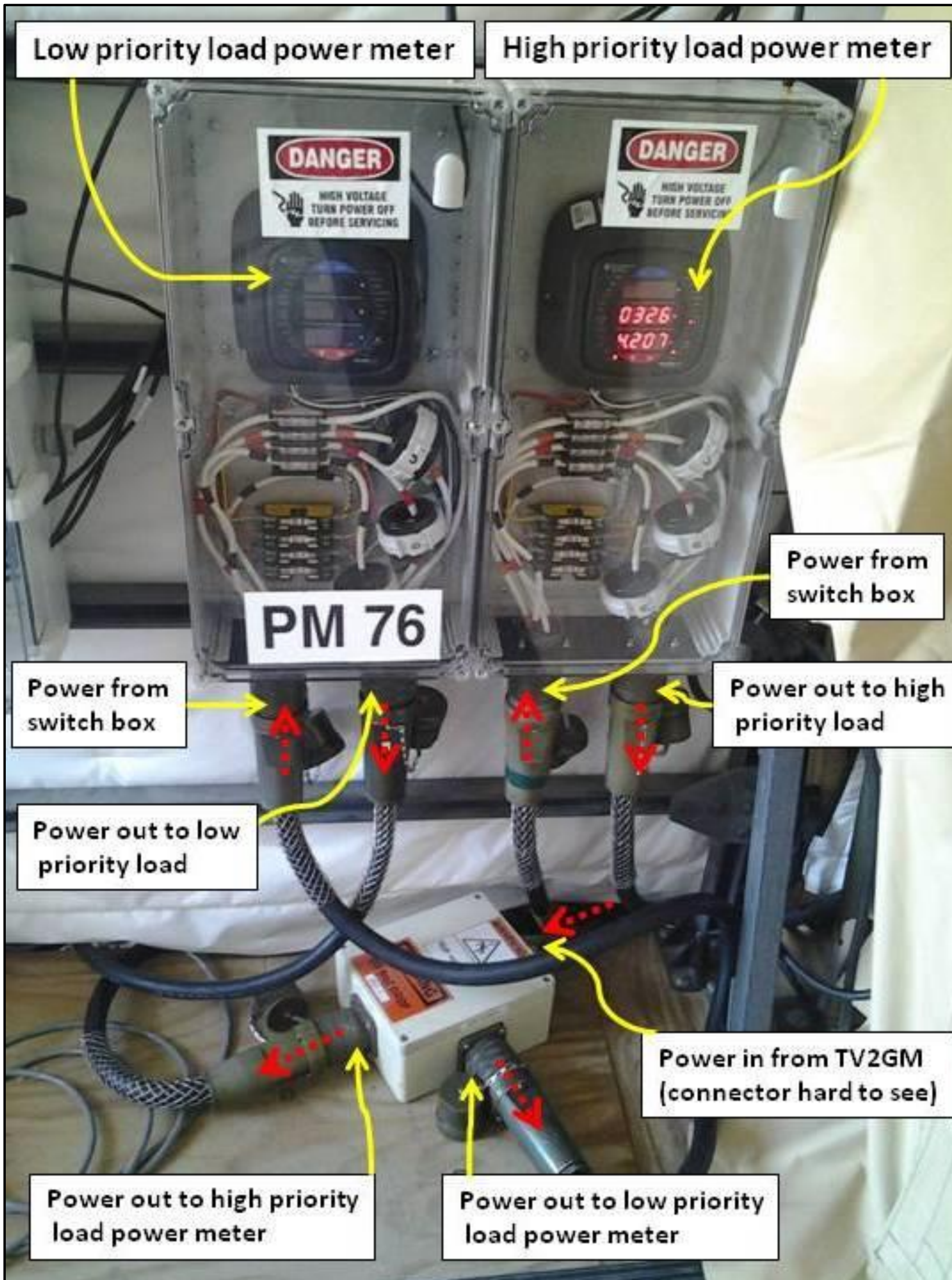

Figure 24: Shark Meter Integrated with North Camp Tent #31

Shark Meters integrated with the billeting tents powered by the TQGs in the South Camp: **Figure 25** shows the typical Shark meter set up in the South Camp tents.

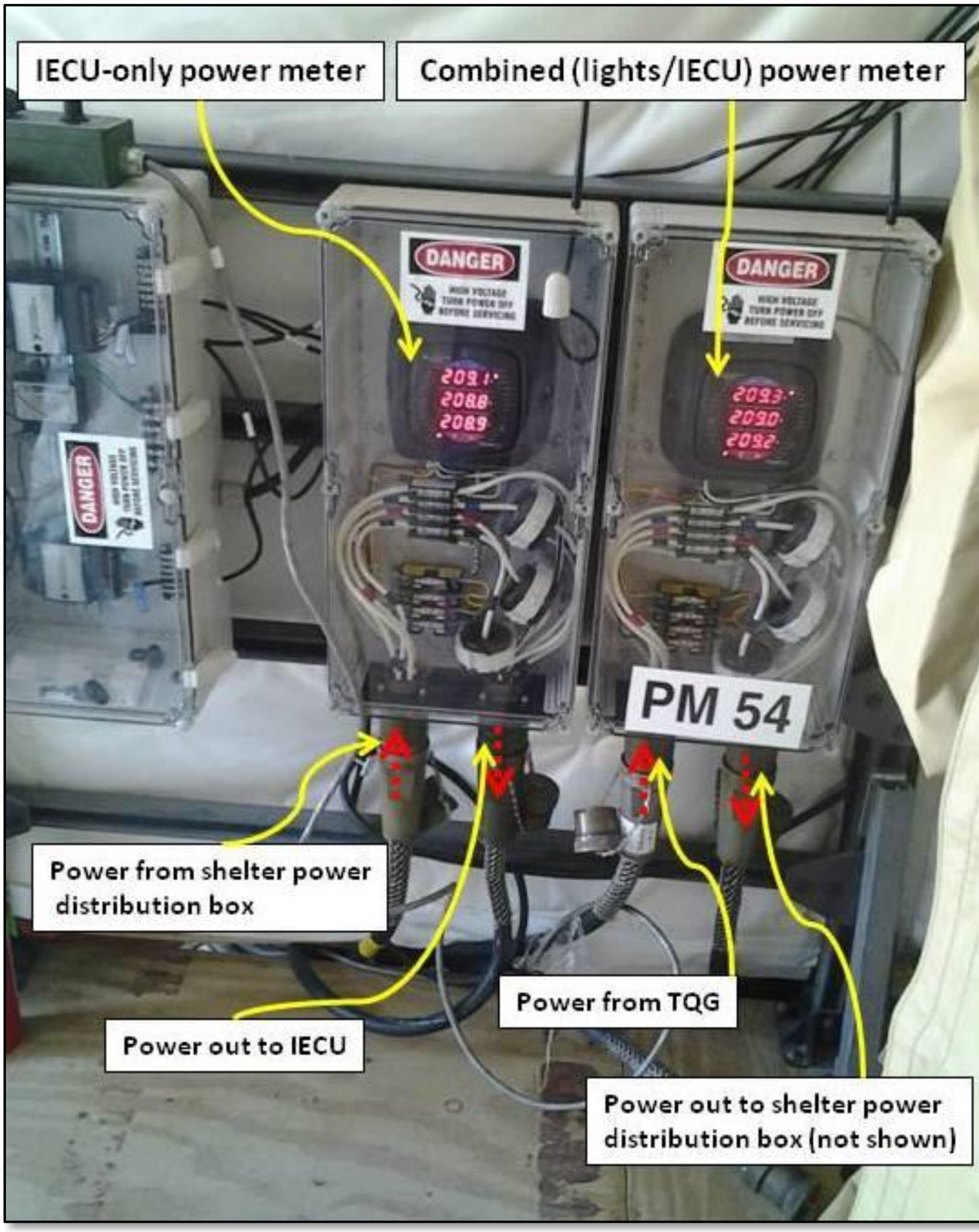

Figure 25: Shark Meter Integrated with South Camp Tent #6

Figure 26 below shows the data path for the Shark meters.

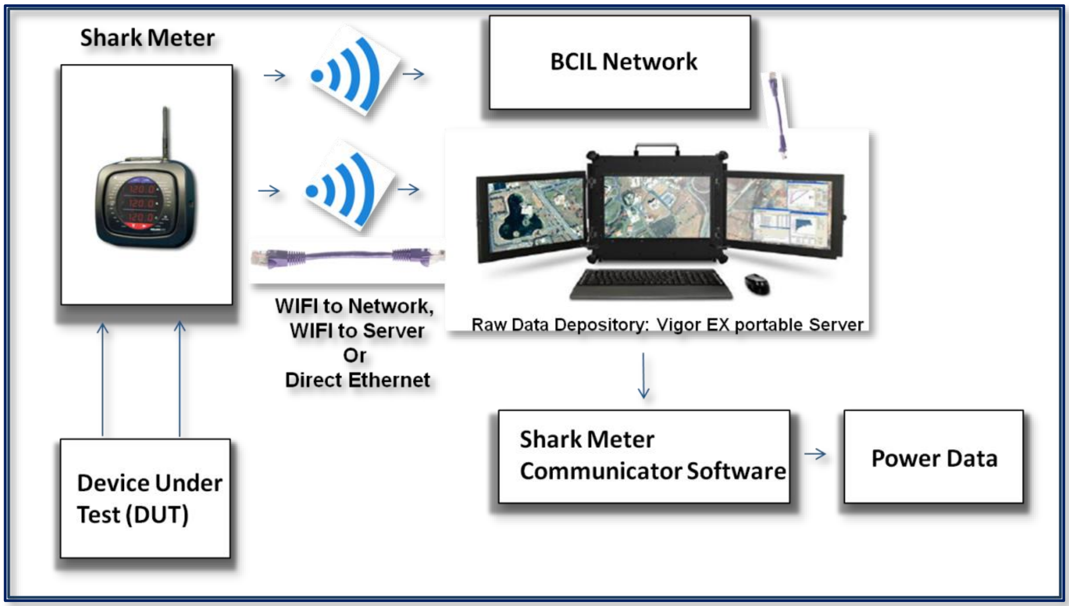

Figure 26: Shark Meter Data Network

3.3.2 National Instruments Nodes and Gateways

The EDVT uses NI Wireless Sensor Network (WSN)-3212 4 Channels, 16-Bit, ±10 V Analog Input Nodes to monitor temperature data. Each node reports to a NI WSN Gateway 9791, which is connected to the local EDVT network.

3.3.3 Thermocouples

The BCIL billeting shelters were instrumented with a number of thermocouples to measure temperature at various locations. The thermocouples were connected to the NI WSN-3212 4 Channels, 24-Bit, Programmable Thermocouple Input Node. It looks very similar to the NI WSN-3202. **Figure 27** is an example of the National Instruments data path for the thermocouples. Further below is a diagram showing a general location of where the thermocouples were placed.

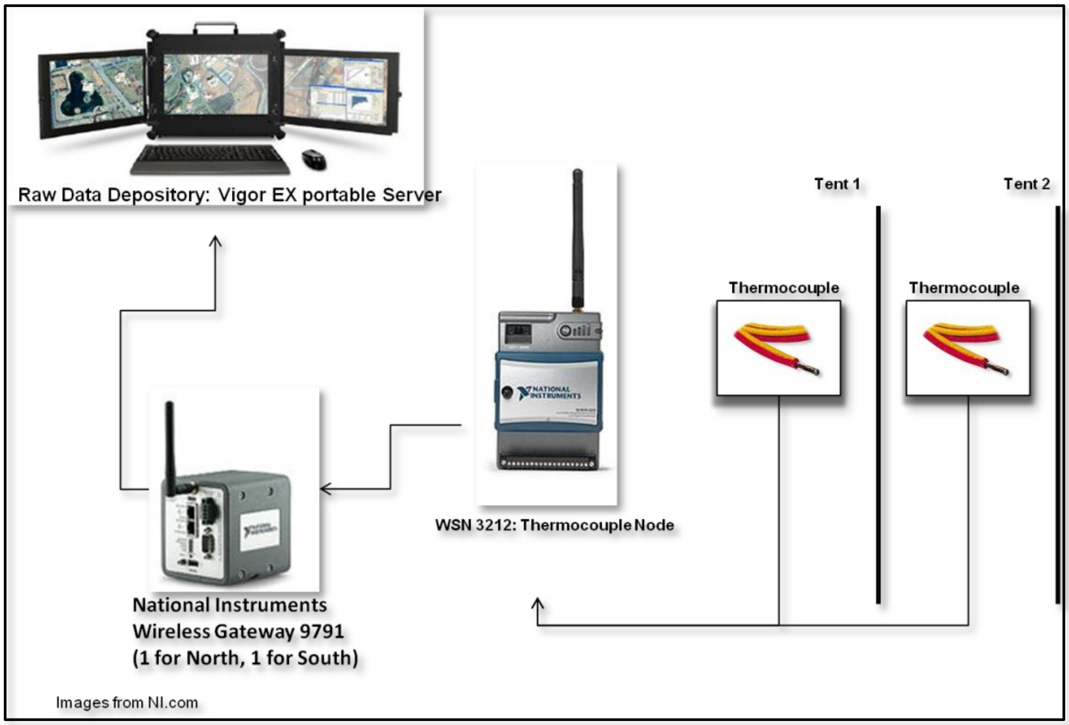

Figure 27: National Instruments Thermocouple Architecture

Tents 5-6, 7-8, 29-30, and 31-32 are grouped into pairs and the thermocouples were placed as shown in **Figure 28**.

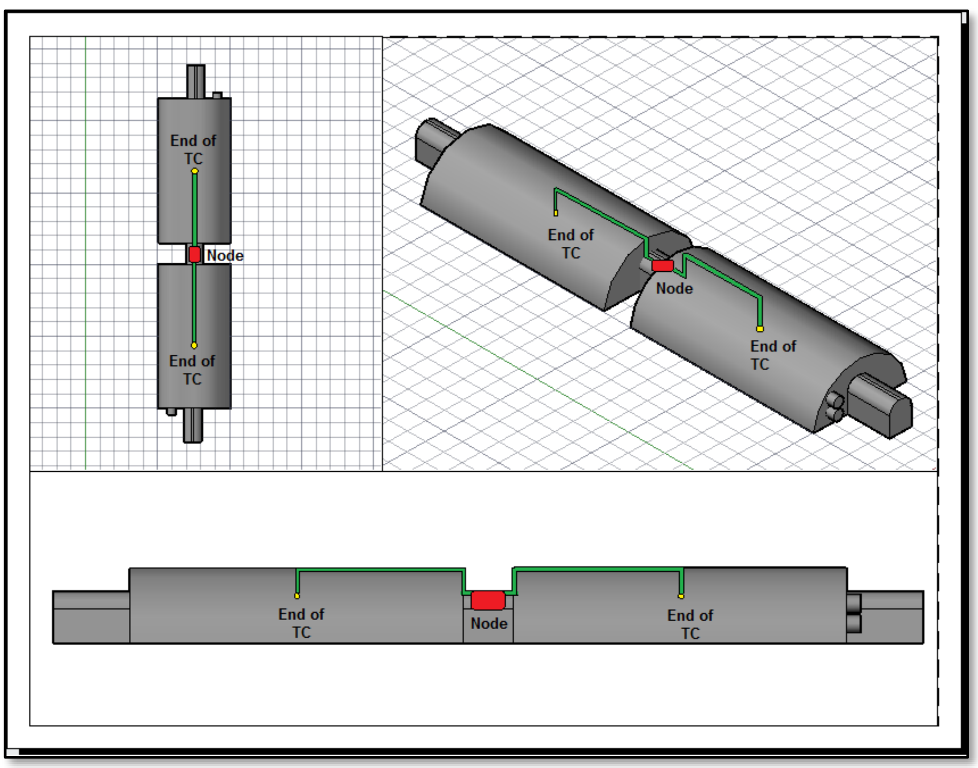

Figure 28: Placement of Thermocouples in Billeting Shelters

Figure 29 is a photo of the installation of the thermocouple in the billeting shelter.

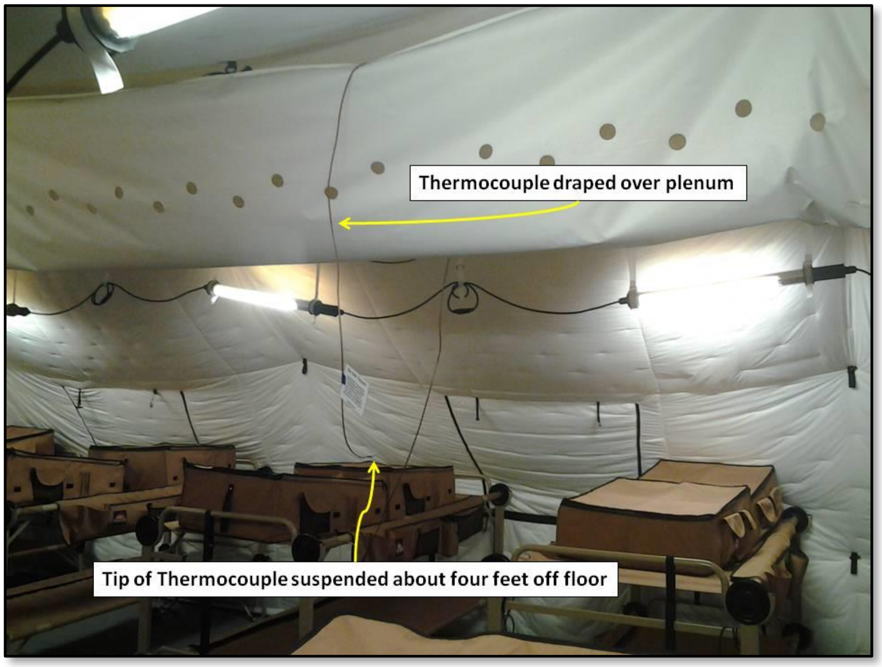

Figure 29: Thermocouple in Billeting Shelter

Figure 30 is a photo of the typical thermocouple node set up between the billeting shelters. This photo includes the gateway.

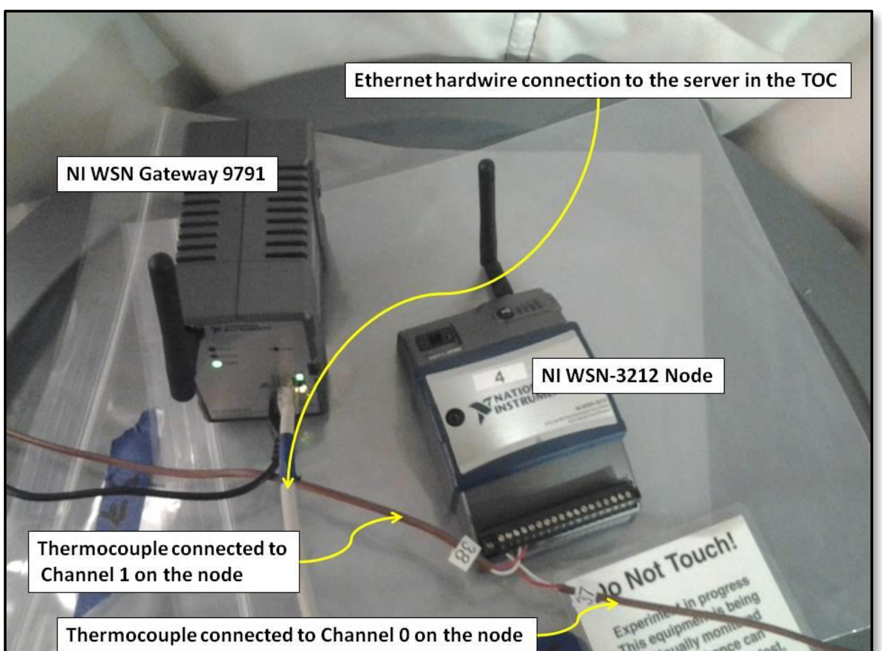

Figure 30: Thermocouple Node and Gateway Set Up

3.3.4 Weight Measurement

There were several weight measurements indicated in the Data Source Matrix (DSM) for this experiment, which required a digital weigh scale to capture those data needs. Thus, a Rugged Wireless Scale (RWS) **(Figure 31)** was specifically designed and built for this application.

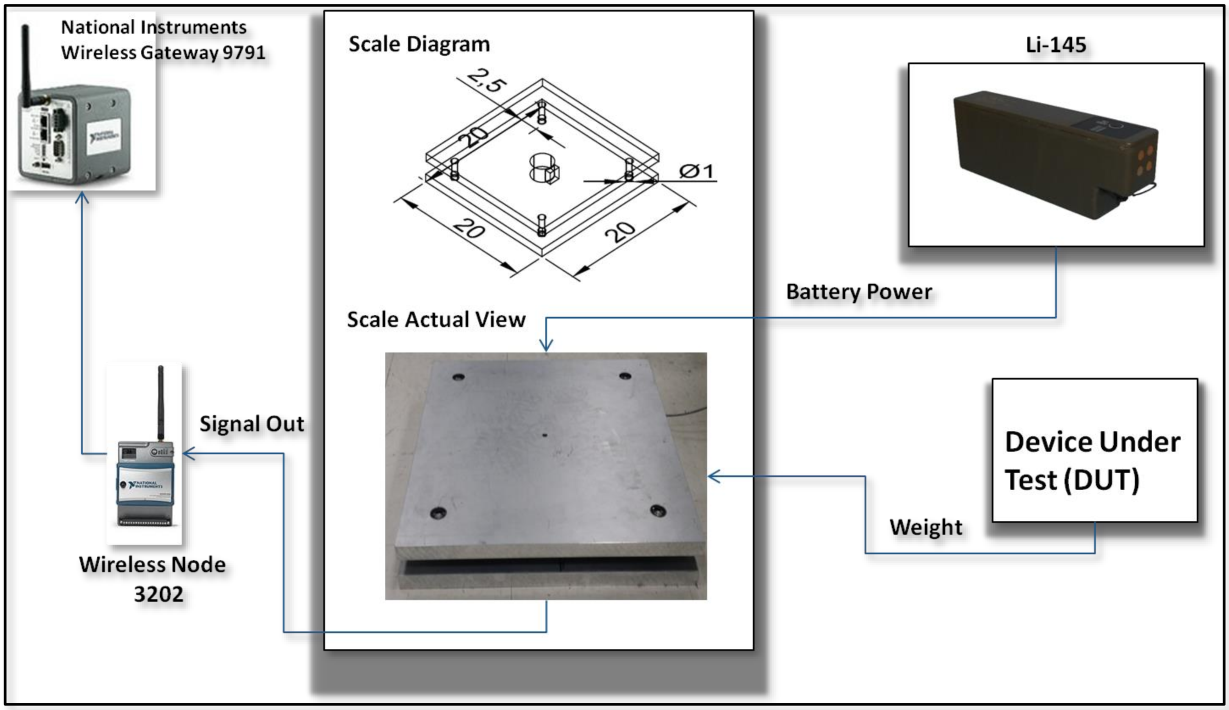

Figure 31: RWS

The scale consists of a Honeywell 41 Load Cell fitted between two 1-inch aluminum plates and supported by four posts with linear bushings. The Load Cell is excited from a circuit that is powered by a Li-145 battery, which outputs approximately a 10-volt full voltage linear scale at maximum weight. The scale can weigh up to 500 lb and was designed to handle a 55-gal drum for trash, fuel, or any other weighing need. However, for this demonstration, the scale was certified to 100 lb at an accuracy of +/- 0.1 lb for a center-load weight. To do so, it was modified with an amplifier between the scale and the 3202 node, to increase the voltage step of the linear scale. To get a higher range of weights, that amplifier can be removed, but the accuracy of the scale will decrease. The scale is designed to work with a National Instruments 3202 Node to capture data. **Figure 31** includes a diagram of the data path and usage of the wireless scale without the amplifier specific to this experiment.

A second commercial scale was used for smaller weight measurements. That item is a Ranger OHAUS scale **(Figure 32)**, which was calibrated at the NSRDEC.

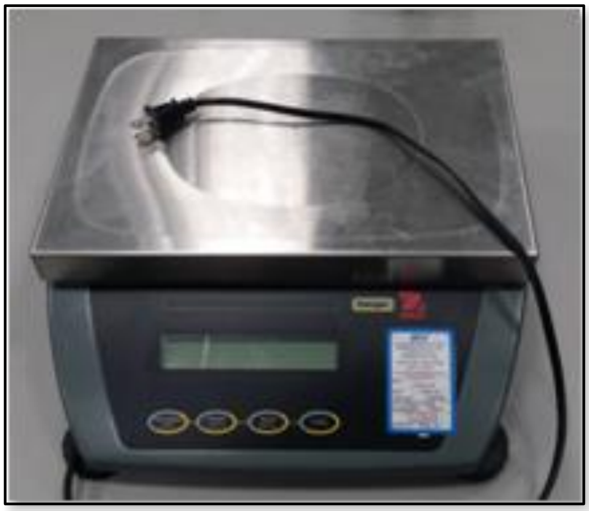

Figure 32: Commercial Scale - Ranger OHAUS

Both scales, RWS and OHAUS, were used to monitor the fuel weights associated with MANGEN operations. The OHAUS was used to weigh external fuel tanks for the PCI and Novatio models and to weigh fuel added to the internal fuel tank of the QinetiQ model. The RWS was used to continually weigh external fuel tanks as MANGENs were operated (**Figure 33**).

Figure 33: MANGEN Fuel Tank on Rugged Wireless Scale

3.3.5 Weather Station

The BCIL has a Davis Vantage Pro 2 **(Figure 34)** weather station with several expansions. The EDVT used the weather station to collect solar radiation, temperature, humidity, wind speed, and rainfall.

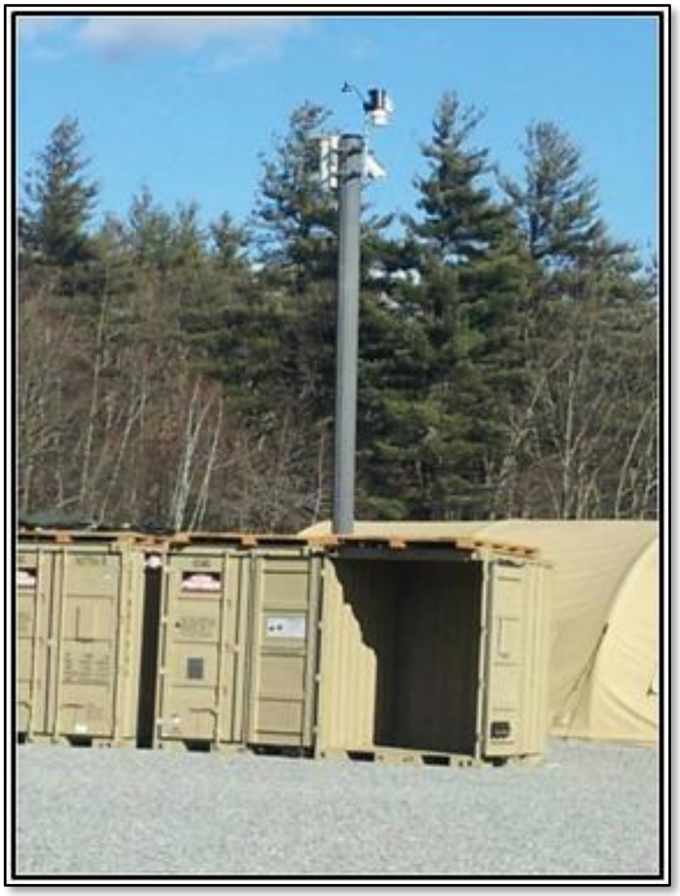

Figure 34: BCIL Weather Station

4. METHODS

This chapter describes the data collection activities and data handling processes from the start of the integrated demo through authentication of the data. Soldier training is also addressed in the Methods chapter.

4.1 Baseline Data Collection

Baseline data elements were collected for Tents #5-8 and the supporting 30kW TQGs. There were no special scripts or requirements for the collection of baseline data. Each day the TQGs in the South Camp were started simultaneously with the OBVP/TV2GM in the North Camp. The TQGs powered the lights and the IECUs for the South Camp tents. Internal tent temperatures were maintained at approximately 68 °F by adjusting the operating mode and potentiometer on the IECU as required. The data collector monitored the thermocouples on the server display in the TOC.

Power data for the billeting shelters were collected by the Shark meters (**Figure 25**) when the South Camp was powered up. IECU power data was collected directly by the specified meter. Total power data (lights and IECU) were collected by the combined power meter.

Fuel data for the TQGs were collected either at the end of the day or before operations the next morning. The mobile diesel fuel supply had a pump and fuel gauge that was used to fill the generator's fuel supply. The volume of fuel was measured to a tenth of a gallon. Fuel data, start times, and stop times for the TQGs were manually entered on a paper data collection form and then transcribed to Excel spreadsheets.

4.2 LINER Data Collection

All billeting shelters in the demonstration, both in the South Camp and the North Camp, had the LINER installed. The shelters were heated, ventilated, or cooled with the IECU. Power and thermocouple data were continuously collected by the instrumentation. There was no separate script required for LINER data collection.

4.3 MANGEN Data Collection

Six MANGEN units were operated each day. Four units each day powered one of four 500W camp lights. A fifth unit powered a battery charger and the sixth unit was connected to a load bank. On two occasions a unit was tasked to power a load in the BCIL training tent consisting of a laptop computer and a projector. Units were rotated through the various loads on a round-robin schedule.

Light set: **Figure 35** shows three of the four MANGENs powering a dedicated camp light during typical operation. The scale used to weigh fuel and fuel tanks can be seen on the table.

Figure 35: MANGENs Powering Camp Lights

Fuel data, start times, and stop times were entered manually on a paper data collection form and then transcribed into Excel spreadsheets. For the MANGEN models with external fuel tanks (PCI and Novatio), the fuel tanks were weighed before starting the generator. The generator was started and the camp light was plugged in. Since the Shark meter was set up in-line with the load, the Shark meter began collecting power data as soon as the MANGEN was started. After operation, the external fuel tank was weighed again to determine the mass of fuel consumed. For the QinetiQ model, the internal fuel tank started full. Then, as required, when the fuel level was low, fuel was weighed in a beaker and added to the fuel tank. At the end of the daily collection period, more fuel was weighed in a beaker and the QinetiQ internal fuel tank was topped off.

Battery Charger: **Figure 33** shows the data collection set up with the MANGEN powering the battery charger (PP-8498/U) and the external fuel tank resting on the RWS. Again, the Shark power meter is in line with the load. Each morning the RWS was calibrated, unless the QinetiQ was scheduled to power the charger. For PCI and Novatio models the external fuel tank was positioned in the center of the RWS. For the QinetiQ model, the data collector ensured the internal fuel tank was full. Six-to-eight discharged BB-2590/U batteries were loaded in the charger. The MANGEN was powered up and the battery charger was plugged in.

Power data were collected by the Shark meter. The battery charger charged two batteries at a time. When batteries were fully charged they were removed from the charger. During a typical day two-to-three batteries would be fully charged.

Fuel weight data were collected continuously by the RWS for the PCI and Novatio MANGENs. Fuel data for the QinetiQ was collected manually by the same method as described above for the light set.

Load Bank and Hot Plate: **Figure 36** shows the QinetiQ MANGEN unit powering the Avtron Model K490 load bank and a commercial hot plate. Since the QinetiQ used only its internal fuel tank, the figure shows no fuel tank on the RWS. When a PCI or Novatio unit was scheduled for this station, then its external fuel tank would be resting on the RWS.

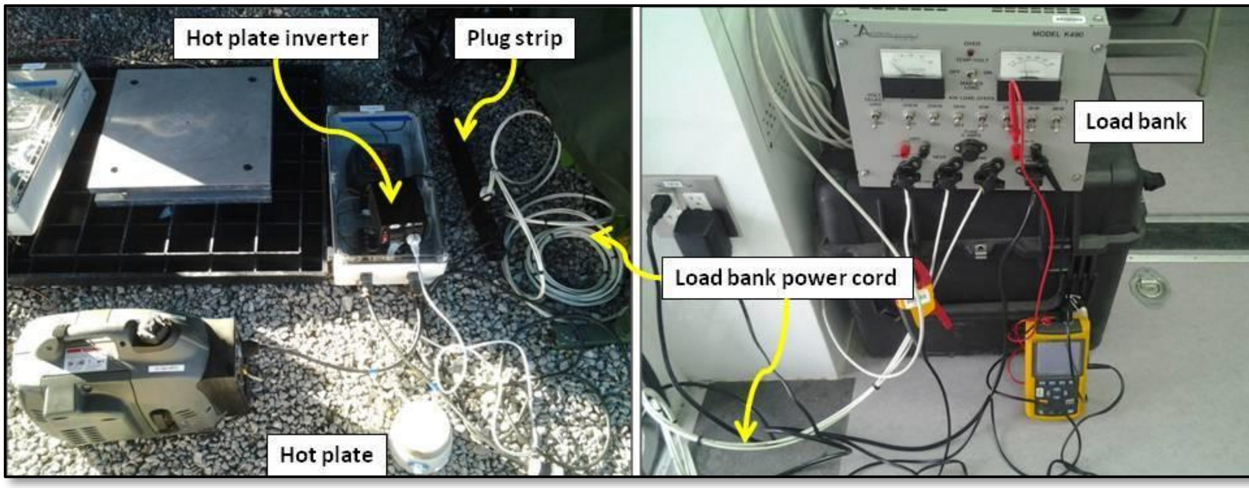

Figure 36: MANGEN Powering Load Bank and Hot Plate

Again, the Shark power meter is in line with the load. The power meter was plugged into the generator and output to a plug strip. The load bank was located just inside the door of the TOC and its power cord was run outside and connected to the power strip. The hot plate, as needed, was plugged into an inverter and the inverter was plugged into the plug strip.

Each morning the RWS was calibrated, unless the QinetiQ was scheduled to power the charger. For PCI and Novatio models the external fuel tank was positioned in the center of the RWS. For the QinetiQ model, the data collector ensured the internal fuel tank was full. The data collector started the MANGEN and then drew varied amounts of power from the generator according to a script by using the switches on the load bank and supplementing with the hot plate as required. Generally, the script followed the sequence:

- Start up at 25% load
- For 30 min increase to 50% load
- For 30 min increase to 75% load
- For 30 min (or less in some cases) increase to 100% load
- Then drop back down to 25% load for 30 min
- Repeat the process by increasing every 30 min until the end of the duty day

Since each MANGEN model has slightly different load capacities, the exact script was a little different for each. The data collector recorded the actual script in the manual data collection forms. Power data were collected by the Shark meter. Fuel weight data were collected continuously by the RWS for the PCI and Novatio MANGENs. Fuel data for the QinetiQ were collected manually by the same method as described above for the light set.

Training tent: On two occasions the EDVT used a MANGEN to power a laptop computer and a projector in the training tent. During these periods the data collectors followed the same data collection procedures as with the camp light.

4.4 REDUCE Data Collection

The REDUCE powered various electrical and electronic systems in the TOC. Four power cords were run from the REDUCE, via pass-throughs in the shelter wall, and terminated in power strips. Laptops, printers, battery chargers, and appliances were plugged into the four power strips. The data collector recorded what systems were plugged into the circuits. (NOTE: The shelter lights and wall-mounted ECU were not powered by the REDUCE but were powered by commercial utility power. The lights had no connectors to plug in and the ECU required three-phase power.)

In the morning, the data collector ensured the generator fuel tank was full. Then the REDUCE was started and power applied to the systems in the TOC. Power data were collected by the Shark meters as shown in **Figure 23**. If the generator ran that day due to lack of sunlight, then fuel data was collected at the end of the day or first thing the next morning when the generator's fuel tank was refilled. In addition to the power and fuel data, the REDUCE had onboard capability to collect (a) battery state of charge, (b) solar power generated, and (c) instantaneous generator power generated.

There was one script developed for operation of the REDUCE and this involved adjusting the angle of the solar panels. This script was executed during operations on 10 October only.

4.5 OBVP/TV2GM Data Collection

The OBVP/TV2GM and its complementary 30kW TQG provided power to a high priority load in the billets (lights, convenience power) and a low priority load (IECUs). Each morning the data collector would ensure the fuel tanks on the OBVP and the TQG were full. Then the OBVP/TV2GM would be started up to distribute power to Tents #29-32. The low priority load was rotated to each IECU every 7 min. (NOTE: The original script called for the power to be rotated to a pair of IECUs every 15 min. However, the software that was delivered for integration with the system failed to allow for two units to be "ON" simultaneously when run in the automatic mode.) The high priority load was held constant, i.e., the lights were always powered as long as the system was running and distributing power. Internal tent temperatures were maintained at approximately 68 °F by adjusting the operating mode and potentiometer on the IECU as required. The data collector monitored the thermocouples on the server display in the TOC.

Power data for the billeting shelters were collected by the Shark meters (**Figure 24**) when the North Camp was powered up. IECU power data on the low priority load was collected directly by the dedicated meter. Likewise, the high priority load power data (lights and IECU) were collected by the dedicated power meter. There was a written script to rotate the different power sources – OBVP, TQG, battery – providing power to the shelters. This script was abandoned

when the system arrived late to the BCIL and missed the first 3 days of data collection. The shelters were powered by the OBVP for 5 days and the TQG for 1 day.

Fuel data for the HMMWV and the TQG were collected either at the end of the day or before operations the next morning. The mobile diesel fuel supply had a pump and fuel gauge that was used to fill the vehicle's and generator's fuel supply. The volume of fuel was measured to the tenth of a gallon. Fuel data, start times, and stop times for the vehicle and TQG were manually entered on a paper data collection form and then transcribed to Excel spreadsheets.

4.6 Environmental Data Collection

General venue environmental data were collected at the weather station node installed at the BCIL. This weather station also interfaced to the BCIL's data collection network and its data were periodically collected and stored in the BCIL's database in the same manner as other sensors.

4.7 Demonstration Incident Reports

The Demonstration Incident Report (DIR) was used to collect data on system and component failures, anomalies, repairs, etc. The DIR was also used to document "administrative" data, such as start times of record runs, site meetings, key stakeholder visits, etc. For this demonstration, paper copies of the DIR data collection form were used. Paper copies were submitted to the Demonstration Director as they were completed. The director reviewed the DIRs daily, entered them into an Excel spreadsheet, and submitted them to the Data Librarian (DL) to be cataloged. DIRs were presented to the Data Authentication Group (DAG) for authentication.

4.8 Soldier Training

During the week of 13 October, seven Soldiers from the 542nd Quartermaster (Force Provider) Company joined the demonstration team. The respective technology providers trained the Soldiers on the MANGEN, REDUCE, and OBVP/TV2GM. The Soldiers were split up into teams of two or three. The Soldier teams rotated through the three technologies, training on a different technology each day. On the last day, 17 Oct, Natick's Consumer Research team conducted a focus group to collect feedback from the Soldiers. **Figure 37** shows the training events.

Figure 37: Soldiers Training on Technologies

4.9 Data Harvesting

The EDVT worked with two types of data: (a) data that were electronically collected by sensors/instrumentation, and (b) data that were collected manually by hand. Data were harvested daily from the electronic sources and delivered daily by the collectors to the SLB-STO-D DL who archived it upon receipt. The DL was responsible for maintaining all data, preparing it for authentication, and reporting to the DAG chair. Throughout the harvesting and reduction process data were stored on a network attached storage (NAS) device. This NAS provided the members of the EDVT with easily accessible secure storage for working on data during the on-site period of the demonstration. Harvesting automatically collected data is easier and will be described first.

4.9.1 BCIL '*basecamp'* Data (Power, Weather) Harvest

The BCIL continuously stores their measurement data in a MySQL database: *basecamp*. Their automated collection and storage of measurement data makes it easy for the EDVT to harvest the collected data needed to support the TECD's objectives. The EDVT previously used the "MySQL Workbench" tool to build a mapping of the DSM data elements to their *basecamp* database locations. For example, humidity is stored as the element *outsideHumidity* in a table named *weather_data* in the *basecamp* database. Correspondingly, the amount of power used by a billeting tent is stored as the element *kWhReceived3Phase*, in a table named *power_data*. That specific billeting tent's power meter would be referred to by its *sensor_id* since all building power data is stored in the same table. Once the mapping was completed, a custom tool was built to read the mapping and, using Structured Query Language (SQL) queries, retrieve data from the BCIL's database. This tool will be used for multiple events since the mapping is independent of the tool and can change from event to event. The retrieval process is shown as process #1 in **Error! Reference source not found.** and was executed daily at the start of the day retrieving data from the previous day.

On the rare occasion(s) when the BCIL infrastructure prevented timely update of the *basecamp* database, power data was retrieved directly from the power meters using the vendor's own tool. That measurement data was substituted for the data that would have been retrieved from the BCIL's *basecamp* database. This process is the same as the process described below for stand-alone power meters.

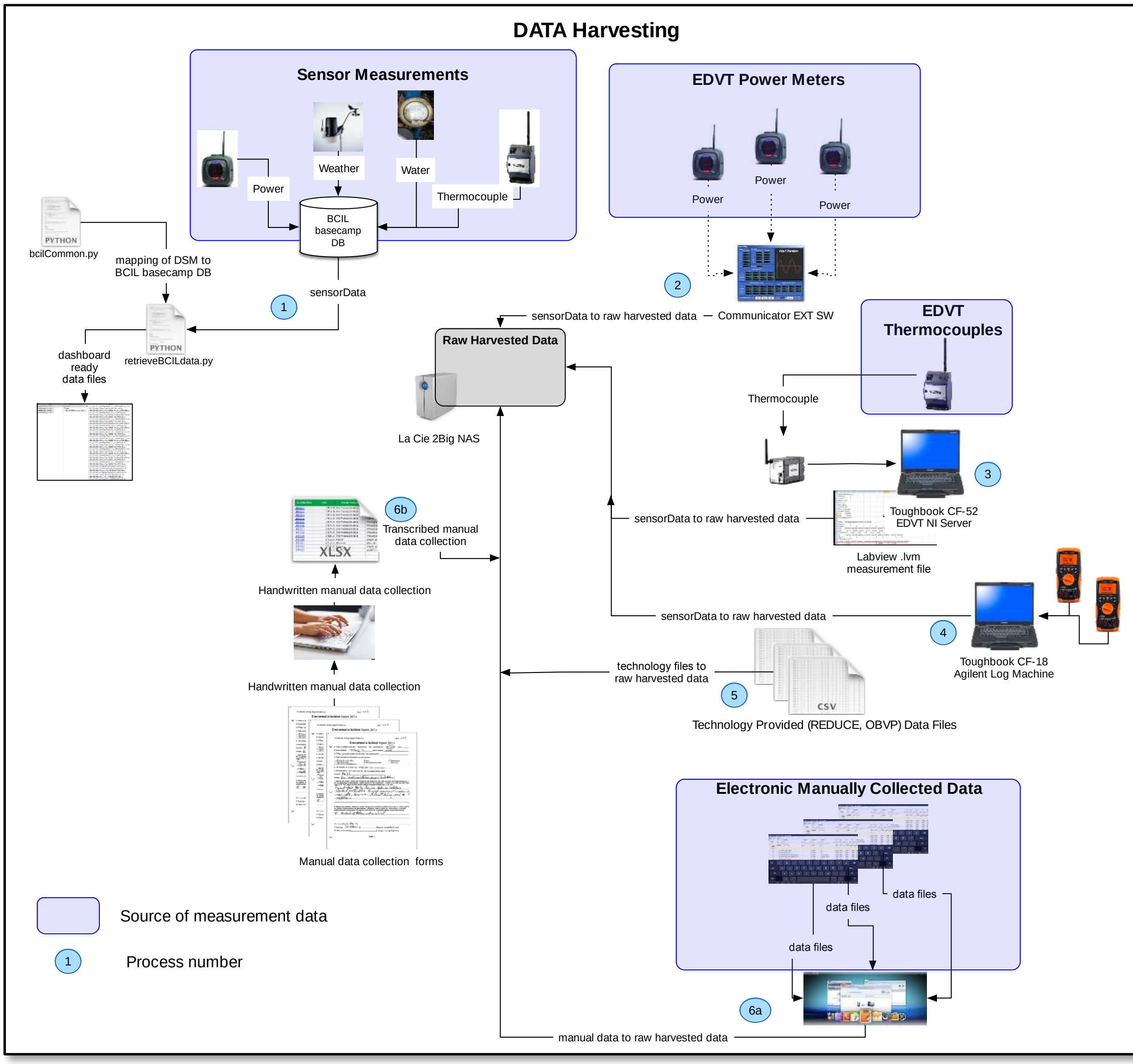

Figure 38: Data Harvest

4.9.2 EDVT AC Power Data Harvest

Some of the 50-person camp technologies (e.g., REDUCE, MANGEN) were not integrated into the BCIL's data collection environment and required the EDVT to collect power data using EDVT-owned Shark meters as described above. Harvesting data from these meters took a completely different approach from the power data harvested from the *basecamp*. For these meters, the EDVT used the vendor-provided tool – Communicator EXT V3.0. This tool is also used to configure the meters but provides an additional mechanism to retrieve the meter's internal data file. The EDVT used this internal meter data as the source of measurement data for these meters since they do not have their values added to the BCIL's database. This is also the same process for the exceptions mentioned above. Each of these internal data files was retrieved

daily and stored in the raw harvested data section of the EDVT NAS. This retrieval process is shown as process #2 in **Error! Reference source not found.**.

4.9.3 EDVT Thermocouple Data Harvest

Some of the technologies in the 50-person camp (e.g. LINER) required the EDVT to collect independent temperature data. The EDVT emplaced its own thermocouples collecting those data using the same type of National Instruments wireless sensor nodes that the BCIL uses. A dedicated EDVT server was used to host the program that controlled, collected, and saved the data to files. These data were also harvested daily and copied to the raw harvested data section of the EDVT NAS. This retrieval process is shown as process #4 in **Error! Reference source not found.**.

4.9.4 Other Demonstration Data Harvest

Some of the technologies (e.g., REDUCE) collect their own system performance data and those data are useful to the TECD. EDVT staff harvested their data and provided it to the DL. Their data was manually added to the EDVT NAS and this process is shown as process #5 in **Error! Reference source not found.**.

4.9.5 Manually Collected Data Harvest

While automated collection is the EDVT’s preference since there is less chance for collection or transcription errors, there are data that could only be collected manually. Some of these data are trivial, like the set points for ECUs. But other data are more complex to manage, like the refueling times, fuel quantities, and the electrical loads on technologies like REDUCE and MANGEN. For these data elements the EDVT must manually collect and document the data in real time. Collectors filled out paper forms that were later transcribed into electronic records. These records were delivered to the DL and placed in the NAS raw data harvest data section. This retrieval process is shown as process # 6b in **Error! Reference source not found.**.

4.10 Data Reduction and Processing

Once harvested, data were reduced and processed. Data sets were reduced to include only the data required. The raw harvested data, described in the previous section, were not yet ready for review by the EDVT, or authentication by the DAG, in their raw harvested form. Many of the harvested data files contain either multiple sensors’ worth of data packaged into a single file or multiple measures from a single sensor. These files required additional processing to structure them into the proper format for review and authentication.

For example, a single file of thermocouple data contained data from two thermocouples. This file was turned into two separate files, each one with identical timestamps but with only a single sensor’s worth of data. A Shark power meter file could contain phase-to-phase: power, voltage, current, energy usage, or power factor, when the TECD may only be required to collect total energy usage and power factor. Data outside the experiment time window were deleted. Data that were collected but not required were also deleted.

The post-harvesting reduction and processing phase works individually with each type of data file and, using the harvested data as an input, produces data in a format that the EDVT has devised known as ‘dashboard ready’. The EDVT uses a custom visualization tool, the Data Review Dashboard (DRD) to review data prior to presenting them to the DAG. At the end of this process, the data were packaged such that environmental and operational data are easily associated with the corresponding technical data and are easily usable by any of the TECD stakeholders.

4.10.1 BCIL ‘basecamp’ Data (Power, Weather) Reduction and Processing

In addition to harvesting the BCIL’s *basecamp* power and weather data, the **retrieveBCILdata.py** tool also performed the post-harvest reduction and processing of the data. Once all of the data had been retrieved, or harvested, the tool built output files for each of the DSM elements. After processing, all files were manually transferred to a ‘dashboard ready files section’ of the EDVT’s NAS. There is a single environmental data (e.g., weather) file that can be used by any of the technologies, and one file per power meter (e.g., OBVP high priority circuit 1, REDUCE circuit 2, etc.). This reduction process is shown as process #1 in **Figure 39**.

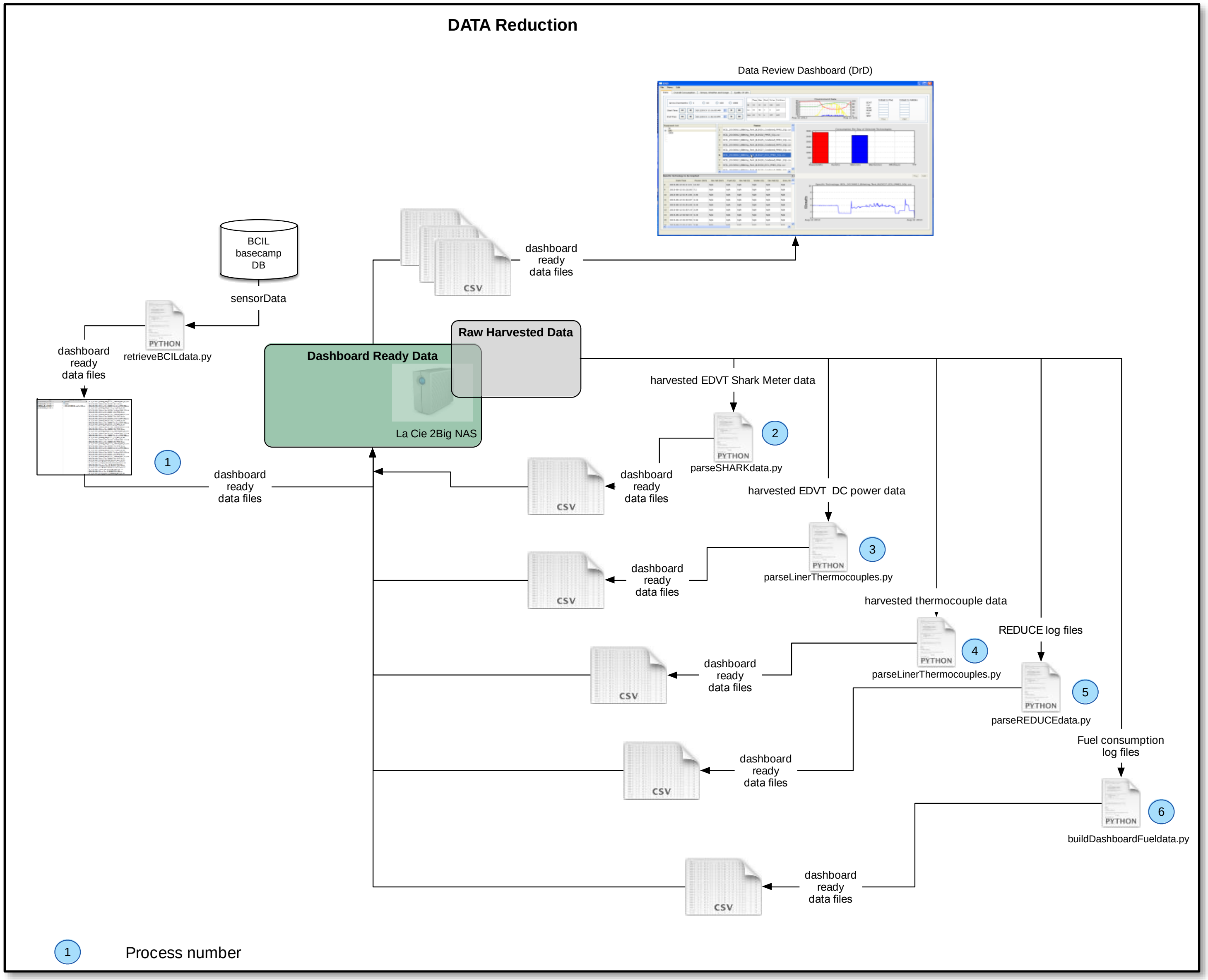

Figure 39: Data Reduction and Processing

4.10.2 EDVT AC Power Data Reduction and Processing

Much of the power data came from the BCIL's *basecamp* database and were reduced as part of their harvesting. REDUCE and MANGEN power data were collected using Shark power meters but the harvested data were in the form of raw, unprocessed internal meter data files. An EDVT tool, **parseSHARKdata.py** was used to extract the DSM related data elements and build dashboard ready files from this data. This reduction process is shown as process #2 in **Figure 39**.

4.10.3 EDVT Thermocouple Data Reduction and Processing

An EDVT tool, **parseLinerThermocouples.py**, previously developed to support LINER experimentation was used to reduce the raw thermocouple data. It created one data file for each thermocouple for each 24-h period. This reduction process is shown as process #4 in **Figure 39**.

4.10.4 Other Demonstration Data Reduction and Processing

The system performance data from the technology internal instrumentation files were in a different format from any of the other collected data. A REDUCE-specific tool, **parseREDUCEdata.py** was developed and tested then used to extract DSM elements (e.g., battery state of charge, solar panel energy generated) from internal REDUCE instrumentation log files. This reduction process is shown as process #5 in **Figure 39**.

4.10.5 Manually Collected Data Reduction and Processing

Some of the manually collected data stand alone and are complete in their harvested format. Examples of this are descriptions of electrical circuit loads and ECU set points. Other data such as fuel consumption data and runtimes were manually aggregated into daily 'roll-up' files and incorporated into the deliverable data set along with all of the measurement data.

Once all of the data were reduced and processed into 'dashboard ready files', the EDVT reviewed the data in preparation for the DAG. Review of data and conduct of the DAG are covered in the next section.

4.11 Data Authentication and Delivery

Three meetings of the DAG were convened to authenticate the collected data. These meetings occurred at the BCIL on 9 Oct, 16 Oct, and 20 Oct, and were conducted according to the established DAG Standard Operating Procedures. During the DAG meetings the voting members from each of the functional teams – CLT, TMIT, SEIT, RIT, EDVT, and MSAT – reviewed the data to ensure they accurately reflected the component and system performance during the demo. Subject matter experts were on hand to answer questions. Good data were scored as "authenticated." Questionable data or data requiring clarification were flagged for further investigation by the EDVT. Twelve Data Investigation Tickets (DIT) were initiated. These are shown in **Table 2** below.

Table 2: Data Investigation Tickets

Serial Number	Date Assigned	General Category	Short Description
DIT 50-001	10/9/2014	tech-provided data	REDUCE generator power not understood, 6 Oct
DIT 50-002	10/9/2014	scale data	P-2, 6 Oct, 1130-1330 system down for maintenance
DIT 50-003	10/9/2014	scale data	N-1, 6 Oct, fuel data
DIT 50-004	10/9/2014	tech-provided data	REDUCE generator power not understood, 7 Oct
DIT 50-005	10/9/2014	scale data	P-1, 7 Oct
DIT 50-006	10/9/2014	EDVT power meter	P-2, 7 Oct, flagged for maintenance period
DIT 50-007	10/9/2014	scale data	Q-1, 7 Oct, remove scale data, no external tank
DIT 50-008	10/9/2014	tech-provided data	REDUCE generator power not understood, 8 Oct
DIT 50-009	10/16/2014	EDVT power meter	Lower than expected Power Data for N2 on 10/9
DIT 50-010	10/16/2014	BCIL power meter	power meter 87 tent 5 looks different than expected
DIT 50-011	10/16/2014	BCIL power meter	missing shark meter data for all tents on 10/10 from 10ish to 11:45.
DIT 50-012	10/16/2014	Thermocouples	thermocouple mapping in tents 31 and 32 on 10/10

After the DAG meetings were complete, the EDVT investigated and resolved the flagged data (except the DITs for REDUCE generator power). The authenticated data files were then compiled, cataloged, and delivered to the SLB-STO-D Lead Systems Engineer. This compilation included generating logs and notes to accompany the delivered dataset so that it can usable by any number of end users. The complete Data Catalog is shown in Annex A.

To researchers, analysts, other end users – Requests for the demonstration data should be made directly to the Lead Systems Engineer. EDVT may not deliver or release data directly. However, EDVT support does not end upon delivery. The EDVT can be contacted if there are any issues parsing or understanding the data that were received from the Lead Systems Engineer.

5. RESULTS AND DISCUSSION

During this 9-day demonstration, the team harvested, processed, and compiled 226 instrument files, 95 captioned photographs, 81 manual data collection forms, 60 Demonstration Incident Reports, and 9 daily data roll up summaries. These were delivered in a compressed (zipped) folder of over 200 megabytes of data that can be used in analysis to assess the contribution of these technologies to the challenge of reducing fuel, water, and waste.

The effort to bring these four technologies together and integrate them with facilities at the BCIL and instrument them for data collection greatly helped mature the project's system engineering processes. The next demonstration will involve ten technologies at a new venue, therefore the established processes are important to efficiently conduct demonstration planning, preparation and execution in a timely manner.

In addition to the collection of data, the project hosted a successful Open House for visitors during which a number of the functional areas were presented. These included Systems Engineering; Modeling, Simulation, and Analysis; Quality of Life; the Technology Portfolio; and Demonstration Planning and Preparation.

Near the conclusion of the demonstration the functional teams came together to conduct an After Action Review (AAR). During this review each team took a critical look at their role in the planning, preparation, and execution of the demonstration. The lessons learned from the AAR are documented under a separate cover. These lessons will be used to improve the processes for the future series of demonstrations.

The sections that follow present the results of the data collection. These sections are not meant to be a substitute for an analysis of the data. The EDVT encourages analysts to apply for copies of the datasets and to conduct analysis of the data in support of the TECD's challenge statement.

5.1 LINER Results

The EDVT conducted baseline comparison experiments with the LINER at the BCIL in March 2016 for heating in cold weather and in July for cooling in hot weather. (NOTE: The reports and authenticated datasets for those previous experiments are available upon request.) The collected data comparing a single-ply (baseline) tent liner to the new LINER showed reduced energy consumption for heating to be around 35% with the new LINER. This data set was then used by the MSAT to calibrate part of TECD's basecamp system model (Virtual Forward Operating Base Detailed Component Analysis Model, or DCAM), and the new LINER was "virtually demonstrated" in three different climate zones, integrated into a representative basecamp system. Comparing overall fuel use of the baseline camp (using the old liner) and the same camp with the new LINER showed a fuel consumption savings of 5% on average, much less than the 35% energy savings on a single tent, but still a significant contribution to the TECD challenge of a 25% fuel savings.

The power data collected during the demonstration in October could be used to augment the previous data. However, it must be kept in mind that a different ECU was employed during this

most recent demonstration. Back in March and July the F-100 ECU was employed, which is part of the TECD FY12 approved baseline and a component of the Force Provider equipment set. But for this most current demonstration, it was switched to the IECU because of its soft start capability and the rotation of power by the OBVP/TV2GM to the IECUs in the North Camp to conserve power and fuel.

5.2 MANGEN Results

During this event, three models of the MANGEN that can burn JP-8 and produce electrical power were demonstrated. It was found that the units are easy to use and are easily portable. The team demonstrated the ability of the units to power camp lights and a battery charger, although there are surely several other reasonable use cases for employing this capability in a basecamp.

During the demonstration, some reliability issues were uncovered that should be corrected before developmental testing. Some systems stalled frequently. One system experienced a failed circuit board. Another had a bent rod causing the generator to fail. There were also a number of incidents attributed to fuel filter issues.

Figure 40 is a representative sample of MANGEN power data plotted over time for a single unit on each of the nine data collection days.

This particular MANGEN rotated through the use case stations as previously described. On 7 Oct, 9 Oct, 14 Oct, and 16 Oct the unit powered a camp light. As expected, the camp light was basically a constant electrical power draw. On 10 Oct, this MANGEN powered a laptop and a projector in the training tent in support of the Open House briefings. The power draw became constant once the computer and projector were running.

On 6 Oct and 15 Oct this unit powered the battery charger. This power draw profile proved to be typical for all MANGEN models. Power draw was greatest when the dead batteries first started charging. Then, power draw dropped as the first battery got a full charge. When the battery charger automatically switched over to the second dead battery, the power draw increased again. The blue line in the plot in **Figure 40** is external fuel tank weight data from the RWS. Unfortunately, the oscillatory nature of this plot makes it hard to see clearly the gradual consumption of fuel during the MANGEN operation. The cause for this oscillation is not known.

On 8 Oct and 17 Oct this MANGEN supplied power to the load bank. The step function can be seen in the power draw corresponding to the script for 25%, 50%, 75% and 100% power draw. In these two charts, for this RWS, the weight data are more stable. There is no oscillation in the fuel weight data that is seen in the other scale.

If just the history of this one unit was examined, it might appear that the fuel weight data are better for one scale than the other. Figures 40-42 attempt to find a common thread.

Figure 41 shows the power and fuel weight data for the load bank each day, except 9 Oct when the QinetiQ unit without the external fuel tank powered the load bank. Most days the fuel weight

plot was a clean line. Clearly on 6 Oct there was some jostling of the fuel tank on the scale. The aberration occurred on 14 October when the plot shows significant instability and/or oscillation.

For comparison, **Figure 42** shows power and fuel weight data for the battery charger each day, except 7 Oct and 16 Oct when the QinetiQ unit without an external fuel tank powered the battery charger. The fuel weight data charts from this scale are more unstable than the other scale.

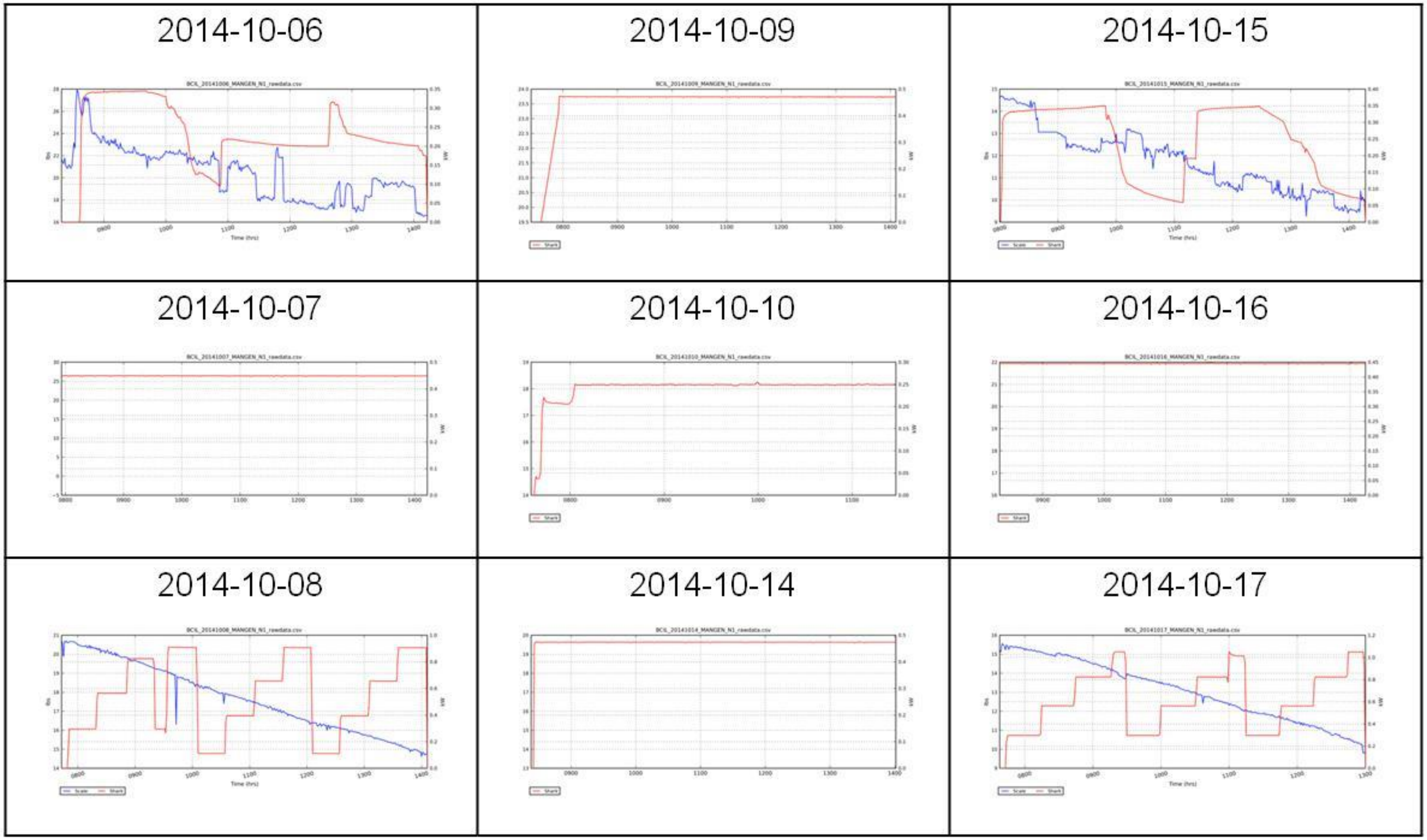

Figure 40: MANGEN Power Plots

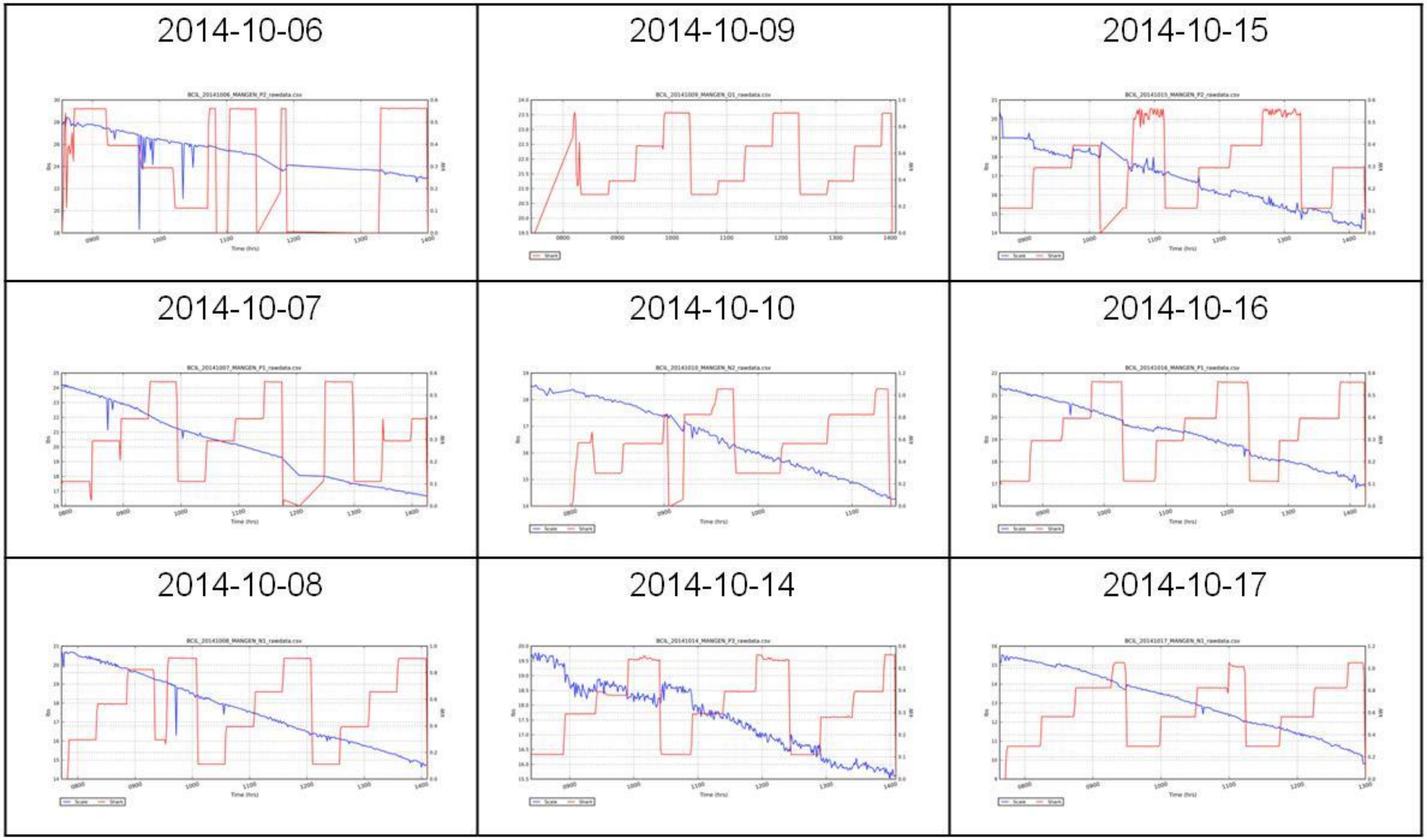

Figure 41: Power and Fuel Weight Data for Load Bank Operation

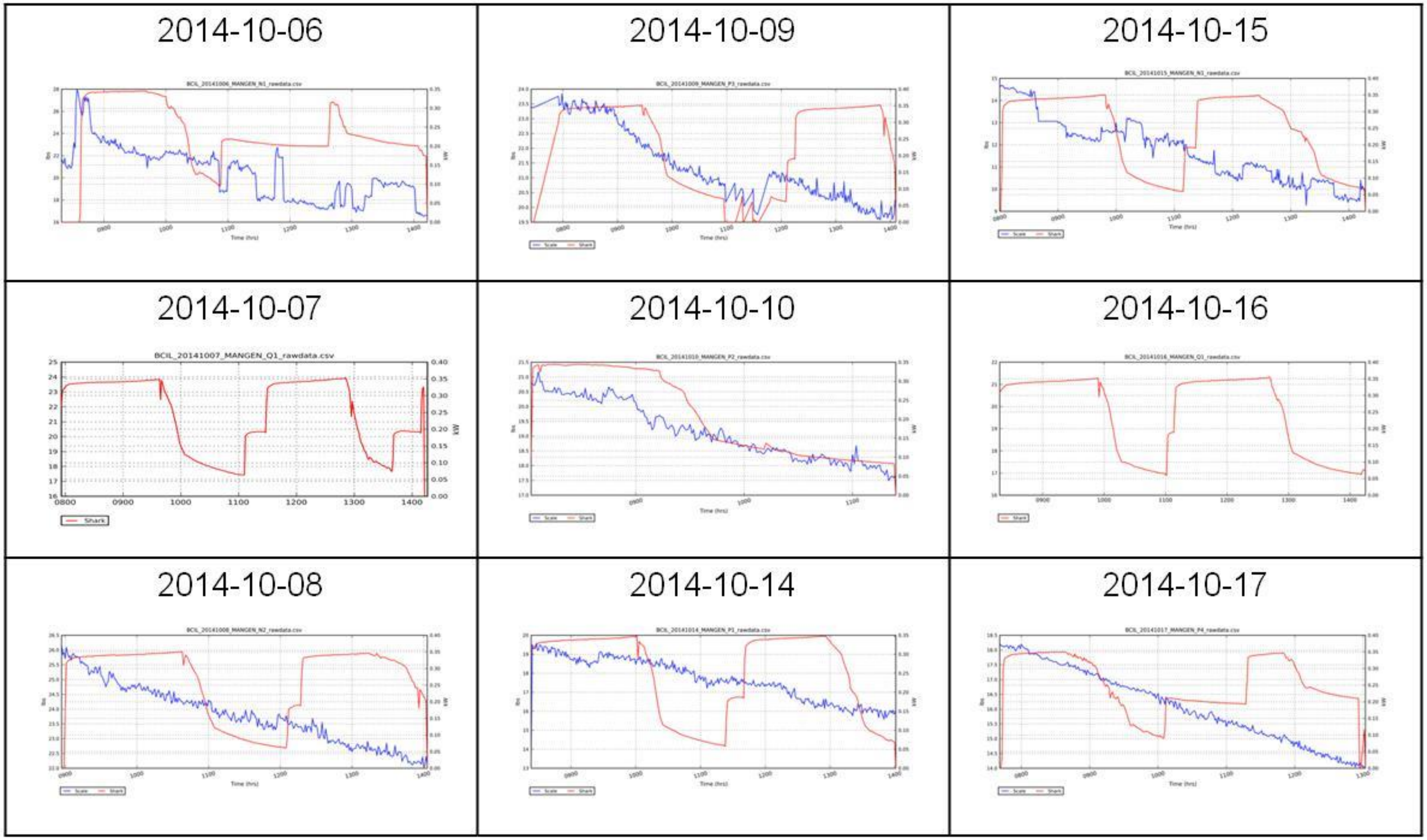

Figure 42: Power and Fuel Weight Data for Battery Charger Operation

More investigation will be required before these scales can be used for similar measurements in the future. For the purpose of this demonstration, the beginning fuel tank weight and final fuel tank weight were used to determine overall consumption each day for that unit.

The following sections summarize the power and fuel data for each of the MANGEN units.

5.2.1 N-1 Results

Table 3 shows the results for unit N-1. This is a Novatio unit with an external fuel tank. The fuel data for 6 Oct were flagged due to the excessive electrical noise in the RWS output.

Table 3: N-1 Results

DATE	POWER (kWh)	RUNTIME (h)	FUEL (lbs)	LOAD
10/6/2014	1.3481	6.00	5.87 (flagged)	battery charger
10/7/2014	3.0007	6.82	5.87	camp light
10/8/2014	3.4643	6.45	6.15	load bank
10/9/2014	3.0061	5.98	4.96	camp light
10/10/2014	0.9597	4.20	2.69	electronic presentation
10/14/2014	2.7486	5.92	4.32	camp light
10/15/2014	1.5198	6.38	4.02	battery charger
10/16/2014	2.9325	6.80	5.02	camp light
10/17/2014	3.2845	5.42	5.04	load bank

5.2.2 N-2 Results

Table 4 shows the results for unit N-2. This is another Novatio unit with an external fuel tank. This unit was designated as a spare. It was placed in the data collection rotation when other units were disabled.

Table 4: N-2 Results

DATE	POWER (kWh)	RUNTIME (h)	FUEL (lbs)	LOAD
10/6/2014				
10/7/2014				
10/8/2014	1.3503	5.20	3.75	battery charger
10/9/2014	1.4203	6.43	4.33	camp light
10/10/2014	1.9846	3.95	4.31	load bank
10/14/2014				
10/15/2014				
10/16/2014	2.7296	6.63	5.14	camp light
10/17/2014	2.3249	5.25	3.72	camp light

5.2.3 P-1 Results

Table 5 shows the results for unit P-1. This is one of the four PCI units. All PCI units had the external fuel tank during demonstration.

Table 5: P-1 Results

DATE	POWER (kWh)	RUNTIME (h)	FUEL (lbs)	LOAD
10/6/2014	1.8514	6.53	5.52	camp light
10/7/2014	1.8514	5.72	5.52	load bank
10/8/2014	2.7941	6.40	5.13	camp light
10/9/2014	2.6973	6.32	5.38	camp light
10/10/2014	1.7027	4.02	3.39	camp light
10/14/2014	1.4074	5.73	4.08	battery charger
10/15/2014	2.9379	6.80	5.46	camp light
10/16/2014	2.0241	6.03	4.43	load bank
10/17/2014	2.3153	5.27	4.22	camp light

5.2.4 P-2 Results

Table 6 shows the results for unit P-2. This unit experienced a number of issues during operations on 7 Oct and these power and fuel data are flagged.

Table 6: P-2 Results

DATE	POWER (kWh)	RUNTIME (h)	FUEL (lbs)	LOAD
10/6/2014	2.0973	3.88	4.26	load bank
10/7/2014	2.09731 (flagged)	4.75	4.15 (flagged)	camp light
10/8/2014	2.9303	6.67	5.43	camp light
10/9/2014	2.7679	6.33	5.45	camp light
10/10/2014	0.7052	3.92	3.72	battery charger
10/14/2014	2.2317	5.55	4.59	camp light
10/15/2014	1.6264	5.43	6.12	load bank
10/16/2014	2.3628	6.12	5.83	camp light
10/17/2014	2.1752	4.78	4.35	camp light

5.2.5 P-3 Results

Table 7 shows the results for unit P-3. This unit suffered a failure on 15 Oct and did not return to the demonstration.

Table 7: P-3 Results

DATE	POWER (kWh)	RUNTIME (h)	FUEL (lbs)	LOAD
10/6/2014	2.9601	6.25	4.94	camp light
10/7/2014	2.9601	6.75	5.26	camp light
10/8/2014	3.1322	6.68	5.22	camp light
10/9/2014	2.7635	6.37	4.25	battery charger
10/10/2014	1.7596	4.00	3.21	camp light
10/14/2014	1.8345	5.77	5.75	load bank
10/15/2014	0.5165	2.05	1.31	camp light
10/16/2014				
10/17/2014				

5.2.6 P-4 Results

Table 8 shows the results for unit P-4. This unit failed during operations, was repaired by the vendor, and returned back to the data collection rotation.

Table 8: P-4 Results

DATE	POWER (kWh)	RUNTIME (h)	FUEL (lbs)	LOAD
10/6/2014	2.9611	6.27	4.95	camp light
10/7/2014	2.9611	6.78	5.24	camp light
10/8/2014				
10/9/2014				
10/10/2014				
10/14/2014	2.3171	5.93	4.23	camp light
10/15/2014	3.1263	6.78	5.41	camp light
10/16/2014	2.7949	6.47	5.2	camp light
10/17/2014	1.3300	5.42	4.20	battery charger

5.2.7 Q-1 Results

Table 9 shows the results for unit Q-1. This is the unit from QinetiQ, which operated using its internal fuel tank.

Table 9: Q-1 Results

DATE	POWER (kWh)	RUNTIME (h)	FUEL (lbs)	LOAD
10/6/2014	1.5507	5.92	4.46	camp light
10/7/2014	1.5507	6.43	4.61	battery charger
10/8/2014	2.8921	6.67	4.53	camp light
10/9/2014	3.1605	6.50	4.63	load bank
10/10/2014	1.7355	3.83	2.70	camp light
10/14/2014	2.4534	6.07	4.26	camp light
10/15/2014	2.6769	6.92	4.28	camp light
10/16/2014	1.4565	6.13	3.85	battery charger
10/17/2014	2.3032	5.28	3.70	camp light

5.3 REDUCE Results

During this event, it was demonstrated that the trailer-mounted hybrid electrical system can harness solar energy and produce electrical power distributed through extension cords. The system was easy to install and straight-forward to operate. The use of a generator to back up the system when enough solar radiation was not available was also demonstrated. However, the generator failed on the eighth day of data collection, even with limited use.

Table 10 is a summary of the fuel and power data for the REDUCE.

Table 10: Summary of REDUCE Results

Date	Run Time (hrs)		Fuel (gal)	Energy Generation (kWh)		Load (kWh)				
	System	Generator	Fuel Usage	Solar	Generator	Circuit 1	Circuit 2	Circuit 3	Circuit 4	Total
10/6/2014	6.90	na	na	3.97	0.96	0.184	1.275	0.297	0.030	1.787
10/7/2014	7.38	na	na	4.09	1.14	0.521	1.165	0.315	0.000	2.001
10/8/2014	7.00	0.57	0.30	3.69	1.86	0.432	1.330	0.323	0.144	2.229
10/9/2014	6.98	na	na	4.49	1.03	0.524	1.304	0.407	0.075	2.309
10/10/2014	4.58	0.57	0.00	3.94	0.98	0.241	1.097	0.194	1.707	3.238
10/14/2014	7.03	2.33	0.40	2.25	3.72	0.417	1.227	0.375	0.799	2.817
10/15/2014	7.23	0.17	0.00	3.33	1.29	0.209	0.804	0.304	0.138	1.455
10/16/2014	4.00	0.99	0.50	0.12	1.90	0.223	0.711	0.180	0.009	1.123
10/17/2014	5.92	na	na	2.84	0.90	0.000	0.363	0.269	0.250	0.881

The system run time is inclusive of the period the REDUCE was providing power to electrical receptacle strips in the TOC. The generator run time indicates the amount of time the generator automatically came on to provide power, e.g., during overcast days when solar radiation was reduced. On 6 Oct, 7 Oct, and 9 Oct, the generator was not required as there was adequate sunlight. On 8 Oct the generator was only required briefly. On 10 Oct and 15 Oct the generator was run during start up just to warm up the generator in case it was needed later. Note that there are no fuel values associated with 10 and 15 Oct. On 14 Oct the generator was required for over 2 h. On 16 Oct the generator emitted black smoke for several minutes and then failed. The technology provider reported that a coupling burned out after many hours due to too much stress. When the generator kicked on it went from 0-3.8kW right away and caused the stress that finally broke the coupling. So on 17 Oct the generator was not available. The values in the Energy Generation section are taken from the onboard data collection capability. The values in the load section were collected by Shark meters.

Figure 43 shows the weather data for 8 Oct. This is important to understand the impact of the weather, i.e., solar radiation, on the operation and performance of the REDUCE system.

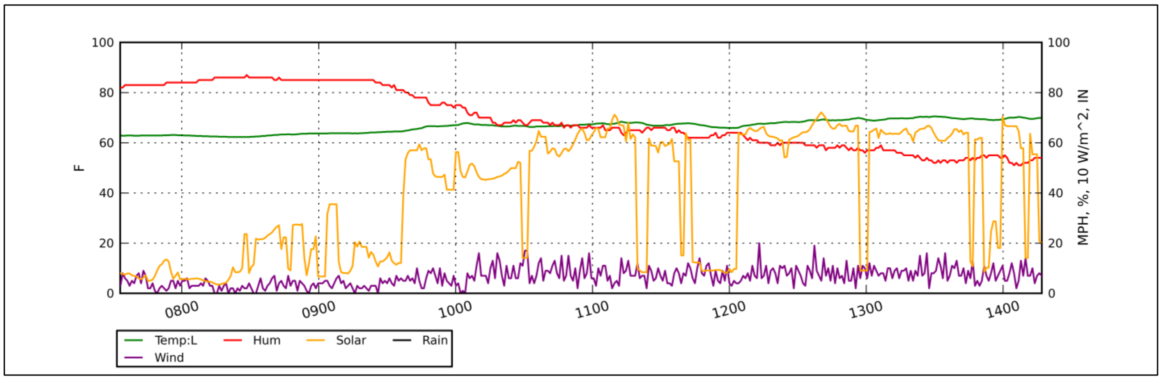

Figure 43: Weather Data Plot for 8 October

Figure 44 shows a compilation of the various data available for REDUCE on a single day, this day being 8 Oct. The upper left section shows the generator power generated by the system. The general weather condition was partly cloudy in the morning (see **Figure 43**), and the generator came on for about half an hour in the mid-morning.

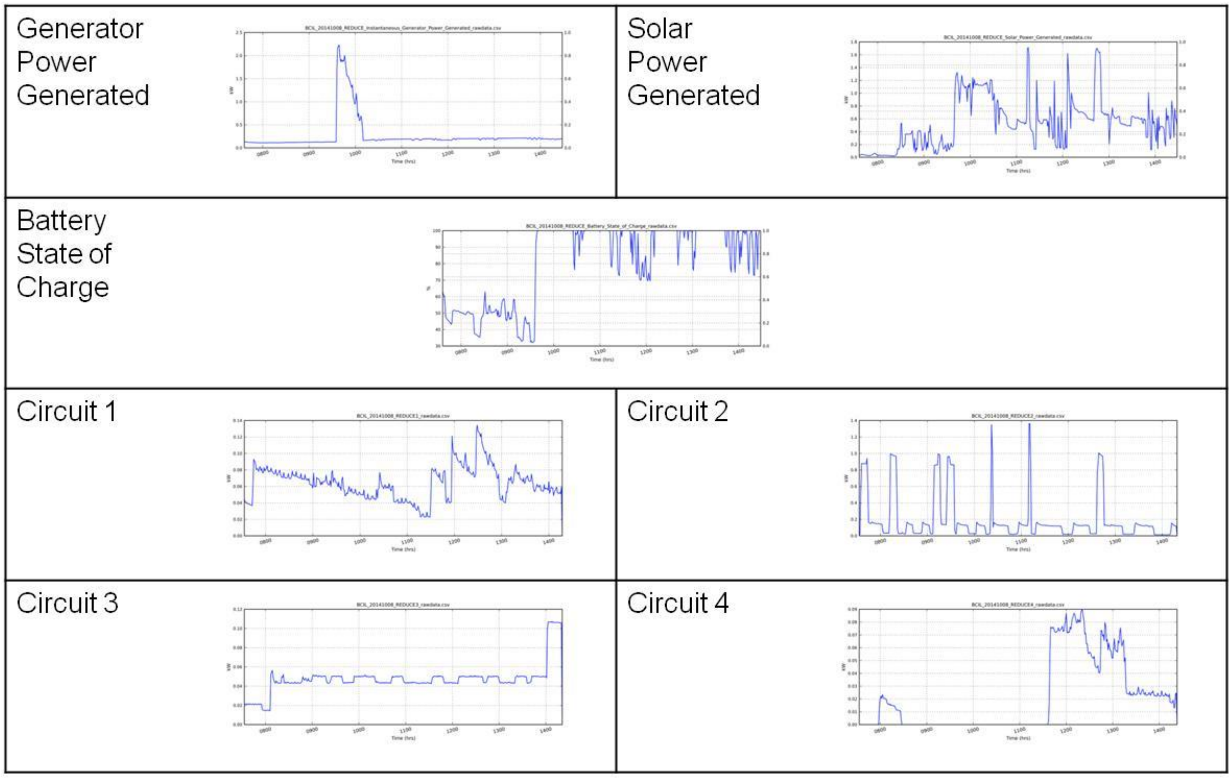

Figure 44: Sample REDUCE Data Plots – 8 October

The upper right section shows the solar power generated. Since it was partly cloudy in the morning, there was not a lot of solar radiation available and the generator kicked on to supplement and bring the battery to a more complete state of charge, the middle section.

The four bottom sections in **Figure 44** show the power profiles for the four circuits in the TOC. Each circuit is a little different based on the types of equipment and appliances plugged into that plug strip.

5.4 OBVP/TV2GM Results

During this event, the team demonstrated the ability of the modified HMMWV to produce and distribute power to high and low priority loads. The concept was to rotate power to different low priority loads while maintaining power to the high priority load. The rotation scheme was not as easy to configure as was hoped, and it was different than what was planned. The plan was to power a pair of IECUs for 15 min, turn them off and power the other two IECUs for 15 min, then repeat. Instead, due to an unexpected condition in the delivered software, the system was scripted to power one IECU for 7 min, turn that IECU off and then power the next IECU for 7 min, etc. On the last day the rotation scheme failed and the technology provider initiated an investigation to determine the cause.

The system was demonstrated in a low power mode and a high power mode. The team also demonstrated the bidirectional capability of the system by running the TQG and charging the

battery. Finally, the use of various power sources was demonstrated by running the TQG during the last record run to provide power to the high and low priority loads without running the HMMWV.

It was identified that more and better use cases for low and high priority loads are needed. Lights in a billeting tent might not be the highest priority. The best operational scenario for a high priority load at a basecamp would likely involve Mission Command systems.

The OBVP/TV2GM was designed to allow a comparison to the SLB-STO-D FY12 approved baseline. As described in Chapter 2, the camp was divided into two sections – the North Camp and the South Camp. The OBVP/TV2GM plus one 30kW TQG powered four tents in the North Camp and two 30kW TQGs powered four tents in the South Camp. The power and fuel data for this side-by-side comparison are shown in **Table 11**.

Table 11: OBVP/TV2GM Power and Fuel Data

	North Camp			South Camp		
Date	Runtime (decimal hours)	Energy (kWh)	Fuel (gal)	Runtime (decimal hours)	Energy (kWh)	Fuel (gal)
10/9	6.52	32.09	13.4	6.42	70.98	15.2
10/10	3.75	23.80	9.2	3.79	60.42	9.4
10/14	5.18	8.90	10.0	5.19	30.98	9.8
10/15	6.05	15.02	6.2	6.05	40.09	11.8
10/16	6.48	12.15	6.3	6.50	12.15	6.3
10/17	5.38	16.83	6.5	5.39	49.02	11.0
	33.36	108.79	51.6	33.32	263.64	63.5

The basic premise would have been that fuel could be saved by powering four tents in the North Camp with only one power source running compared to the baseline South Camp, which had two power sources running at all times. Fuel consumed by the HMMWV in the North Camp on 9 Oct, 10 Oct, and 11 Oct is not considerably different from the combined fuel consumed by the TQGs in the South Camp, and certainly not half. On 15 Oct, the OBVP/TV2GM was switched from a high power mode to a low power mode, with reduced engine speed, and the fuel savings was considerable: 6.2 gal vs. 11.8 gal. On 16 Oct, there was an issue with the load-management software. The program for rotation of low priority loads was erased. So the system was operated in Manual Mode, allowing all four IECUs to run simultaneously in VENT mode. It can be seen that total power draw and fuel was the same for both camps that day. On 17 Oct, the team demonstrated the capability of the OBVP/TV2GM to integrate other power sources by running a single 30kW TQG instead of the HMMWV. With one TQG in the North compared to two in the South, the fuel savings was significant.

These data are graphed in **Figure 45**.

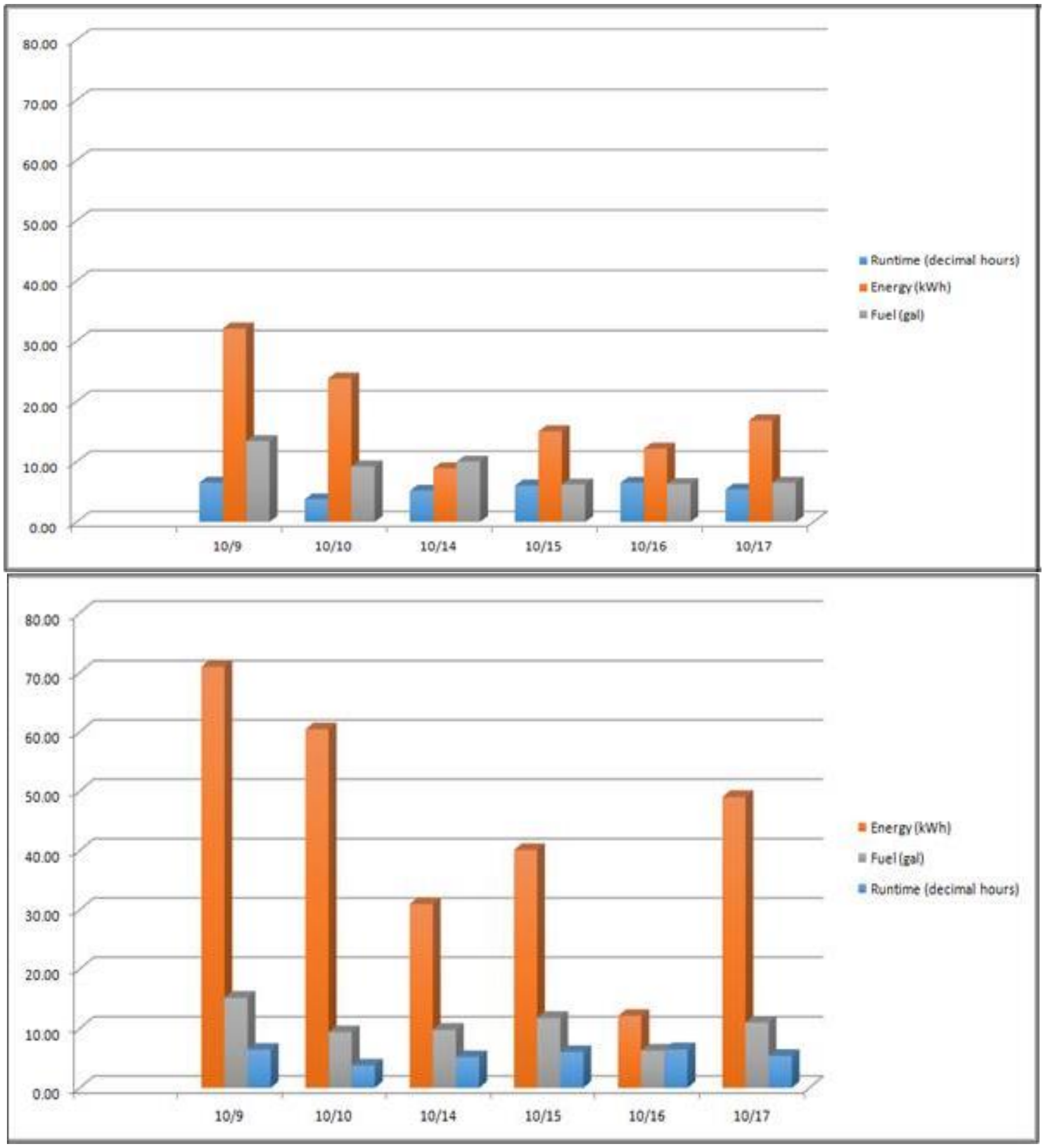

Figure 45: Power and Fuel Data Graph for North and South Camps (l to r)

5.6 Soldier Feedback Results

Soldiers from the 542nd Quartermaster Company (Force Provider) were trained on the demonstrated technologies and provided input in the areas of ease of set-up, maintenance, noise signature, priority of electrical loads, vulnerabilities, and potential operational use. The Soldiers' feedback was recorded and made available to technology providers for future improvements. Results of the Soldier focus group conducted by the Consumer Research Team (CRT) are found at Annex B.

6. CONCLUSIONS

The chief objective of this demonstration was to: “Collect empirical data on candidate technologies and baseline systems that can be used to calibrate modeling, simulation, and analysis, and support trade-offs and engineering decisions.” This objective was met and the datasets have been delivered. These data will be used by the TECD in modeling, simulation, and analysis (refer to the Analytical Framework in **Figure 1**) to show the contribution of the demonstrated technologies to the overall challenges of saving fuel consumed at contingency basecamps. Results of the modeling and simulation will be published in future reports.

This demonstration featured four technologies that show potential to fill contingency basing and operational energy gaps. The LINER makes the billeting shelters more energy efficient, thus reducing the power required by ECUs to maintain internal temperatures. The MANGEN provides an operational energy capability in the 1kW range that is currently not available to deployed units. The REDUCE harvests solar energy to supplement a camp’s power grid and thus reduce the amount of fuel required to operate generators. And the OBVP/TV2GM provides a mobile power source with distribution management required during the initial stages of establishing a basecamp. Soldiers from the 542nd Quartermaster Company (Force Provider) were trained on the demonstrated technologies and provided input in the areas of ease of set-up, maintenance, noise signature, priority of electrical loads, vulnerabilities, and potential operational use.

Power data collected and authenticated in March showed reduced energy consumption for heating to be around 35% with the new LINER. This data set was used to calibrate part of DCAM and the new liner was then "virtually demonstrated" in three different climate zones, integrated into a representative basecamp system. Comparing fuel use of the baseline camp (using the old liner) and the same camp with the new LINER showed an overall fuel consumption savings of 5% on average, a significant portion of the TECD goal of 25% fuel savings.

The MANGEN demonstrated that it can burn JP-8 and produce electrical power. The Soldiers found that the generators are easy to use and are easily portable. Soldiers had many positive comments and suggested the MANGENs should be employed for duty in locations such as guard towers and motorpools.

The REDUCE demonstrated that the trailer-mounted hybrid electrical system can harness solar energy and produce electrical power distributed through extension cords. Soldiers found that the system was easy to install and straight-forward to operate. The Soldiers liked the quiet operation of the REDUCE when power was supplied from the battery.

The OBVP/TV2GM successfully demonstrated an initial entry capability to provide, manage, and distribute power to a basecamp early in its construction. The Soldiers found great benefit with this mobile power-production capability. As for fuel savings, more work is required to identify the proper low and high priority loads for switching power on and off while maintaining critical camp functions.

By all measures, this initial demonstration was a success. This integrated demonstration event saved Army resources. Venue coordination, logistics, integration with other systems and technologies, stakeholder engagements, data collection, and data authentication are done collectively, rather than requiring each individual project officer to organize and execute their own demonstration event. The demonstration allowed the RDECs to encounter the challenges of integration in a "field" environment and to expose their technologies to Soldiers, who provided valuable feedback to improve their technologies, thus creating a "Win-Win" situation that can shorten the development and maturation cycles of the demonstrated technologies.

The SLB-STO-D, and specifically the EDVT, learned a number of lessons during planning, preparation, and execution that will improve future demonstrations. The SLB-STO-D's data management processes were key to the success of this demo. These processes will continue to improve with experience as all functional teams dedicate the right manpower and resources early in the demonstration planning phase to identify and track the required data elements.

This document reports research undertaken at the U.S. Army Natick Soldier Research, Development and Engineering Center, Natick, MA, and has been assigned No. NATICK/TR- 17/022 in a series of reports approved for publication.

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LIST OF ACRONYMS

AAR	After Action Review
AC	Alternating Current
BAH	Booz Allen Hamilton, Inc.
BCIL	Base Camp Integration Laboratory
C2	Command and Control
CASCOM	Combined Arms Support Command
CBITEC	Contingency Basing Integration and Technology Evaluation Center
CERDEC	Communications-Electronics Research, Development and Engineering Center
CERL	Construction Engineering Research Laboratory
CLT	Core Leadership Team
CP	Command Post
CRT	Consumer Research Team
DAG	Data Authentication Group
DAMP	Demonstration and Assessment Master Plan
DCAM	Detailed Component Analysis Model
DCS	Digital Control System
DIR	Demonstration Incident Report
DIT	Data Investigation Ticket
DL	Data Librarian
DRD	Data Review Dashboard
DSM	Data Source Matrix
E2RWS	Energy Efficient Rigid Wall Shelter
ECU	Environmental Control Unit
EDVT	Experimentation, Demonstration, and Validation Team
ERDC	Engineer Research and Development Center
FPE	Force Provider Expeditionary
GDIT	General Dynamics Information Technology
HMMWV	High Mobility Multipurpose Wheeled Vehicle
IECU	Improved Environmental Control Unit
IMS	Integrated Master Schedule
LINER	Non-woven Composite Insulation Liner
LTT-F	Light Tactical Trailer-Flatdeck
MANGEN	1kWe JP-8 fueled, Man-Portable Generator Set
MBSE	Model Based System Engineering
MEP	Mobile Electric Power
MSAT	Modeling, Simulation, and Analysis Team
NAS	Network Attached Storage
NI	National Instrument
NSRDEC	Natick Soldier Research, Development and Engineering Center
OBVP/TV2GM	Onboard Vehicle Power/Tactical Vehicle-to-Grid Module

OE	Operational Energy
ORTB	Operationally Relevant Technical Baseline
PCI	Precision Combustion Incorporated
PdM FSS	Product Manager Force Sustainment Systems
PM E2S2	Program Manager Expeditionary Energy and Sustainment Systems
POR	Program of Record
RDEC	Research, Development, and Engineering Center
REDUCE	Renewable Energy for Distributed Under-supplied Command Environments
RIT	Requirements Integration Team
RWS	Rugged Wireless Scale
SCPL	Single Common Powertrain Lubricant
SEIT	Systems Engineering and Integration Team
SEP	Systems Engineering Plan
SLB-STO-D	Sustainability Logistics Basing Science and Technology Objective-Demonstration
SV	System View
SQL	Structured Query Language
TARDEC	Tank and Automotive Research, Development and Engineering Center
TECD	Technology-Enabled Capability Demonstration
TEMPER	Tent, Extendable, Modular, Personnel
TMIT	Technology Maturation and Integration Team
TOC	Tactical Operations Center or TECD Operations Center
TQG	Tactical Quiet Generator
ULCANS	Ultra-Lightweight Camouflage Net System
WSN	Wireless Sensor Network

ANNEX A – Data Catalog

The Data Catalog is an Excel file embedded below.

Demo1-50 Composite
Logbook (10-06 to 10

The same Data Catalog is also pictured in the tables that follow.

Serial Number	General Category	Filename (if applicable)	Detailed Description	POC	Authentication Code	Date Authenticated	Date Delivered	Comments
Demo1-50-001			DataSet Monday 10/06/2014					
	Dashboard Data Output		Authenticated power data ready for analysis	Benasutti				
		BCIL_20141006_Billeting_Tent_BLDG05_Combined_PM64_DRD.csv		Benasutti	Authenticated	9-Oct-14		This file was authenticated by the EDVT. The file presented during the DAG was actually the file for the ECU-only power meter. The filenames were incorrect. The filenames have since been corrected.
		BCIL_20141006_Billeting_Tent_BLDG06_Combined_PM54_DRD.csv		Benasutti	Authenticated	9-Oct-14		
		BCIL_20141006_Billeting_Tent_BLDG07_Combined_PM75_DRD.csv		Benasutti	Authenticated	9-Oct-14		
		BCIL_20141006_Billeting_Tent_BLDG08_Combined_PM74_DRD.csv		Benasutti	Authenticated	9-Oct-14		
		BCIL_20141006_MANGEN_N1_DRDdata.csv		Benasutti	Authenticated	9-Oct-14		Power data are authenticated. Fuel weight data are not authenticated.
		BCIL_20141006_MANGEN_P1_DRDdata.csv		Benasutti	Authenticated	9-Oct-14		
		BCIL_20141006_MANGEN_P2_DRDdata.csv		Benasutti	Authenticated	9-Oct-14		
		BCIL_20141006_MANGEN_P3_DRDdata.csv		Benasutti	Authenticated	9-Oct-14		
		BCIL_20141006_MANGEN_P4_DRDdata.csv		Benasutti	Authenticated	9-Oct-14		
		BCIL_20141006_MANGEN_Q1_DRDdata.csv		Benasutti	Authenticated	9-Oct-14		
		BCIL_20141006_REDUCE1_DRDdata.csv		Benasutti	Authenticated	9-Oct-14		
		BCIL_20141006_REDUCE2_DRDdata.csv		Benasutti	Authenticated	9-Oct-14		
		BCIL_20141006_REDUCE3_DRDdata.csv		Benasutti	Authenticated	9-Oct-14		
		BCIL_20141006_REDUCE4_DRDdata.csv		Benasutti	Authenticated	9-Oct-14		
		BCIL_20141006_REDUCE_Battery_State_of_Charge_DRDdata.csv		Benasutti	Authenticated	9-Oct-14		
		BCIL_20141006_REDUCE_Instantaneous_Generator_Power_Generated_DRDdata.csv		Benasutti	Authenticated	9-Oct-14		
		BCIL_20141006_REDUCE_Solar_Power_Generated_DRDdata.csv		Benasutti	Authenticated	9-Oct-14		
	Weather Data	BCIL_20141006_weather_SQL.csv	Authenticated weather data ready for analysis	Krutsch	Authenticated	9-Oct-14		
	Daily Summary	Manual_Data_Rollup_20141006.xlsx	Collection from roughly 07:30 to 14:30 Contains DIRs 50-001 to 50-005 Contains DITs 50-001 to 50-003 Summary performance data for MANGENs, REDUCE and 30kW generators on South Camp	Krutsch	Limited Use	N/A		
Demo1-50-002			DataSet Tuesday 10/07/2014					
	Dashboard Data Output		Authenticated power data ready for analysis	Benasutti				
		BCIL_20141007_MANGEN_N1_DRDdata.csv		Benasutti	Authenticated	9-Oct-14		
		BCIL_20141007_MANGEN_P1_DRDdata.csv		Benasutti	Authenticated	9-Oct-14		
		BCIL_20141007_MANGEN_P2_DRDdata.csv		Benasutti	Authenticated	9-Oct-14		
		BCIL_20141007_MANGEN_P3_DRDdata.csv		Benasutti	Authenticated	9-Oct-14		
		BCIL_20141007_MANGEN_P4_DRDdata.csv		Benasutti	Authenticated	9-Oct-14		
		BCIL_20141007_MANGEN_Q1_DRDdata.csv		Benasutti	Authenticated	9-Oct-14		Flagged during DAG because file contained scale data that did not apply. Scale data removed from file (DIT 50-007).
		BCIL_20141007_REDUCE1_DRDdata.csv		Benasutti	Authenticated	9-Oct-14		
		BCIL_20141007_REDUCE2_DRDdata.csv		Benasutti	Authenticated	9-Oct-14		
		BCIL_20141007_REDUCE3_DRDdata.csv		Benasutti	Authenticated	9-Oct-14		
		BCIL_20141007_REDUCE4_DRDdata.csv		Benasutti	Authenticated	9-Oct-14		
		BCIL_20141007_REDUCE_Battery_State_of_Charge_DRDdata.csv		Benasutti	Authenticated	9-Oct-14		
		BCIL_20141007_REDUCE_Instantaneous_Generator_Power_Generated_DRDdata.csv		Benasutti	Authenticated	9-Oct-14		
		BCIL_20141007_REDUCE_Solar_Power_Generated_DRDdata.csv		Benasutti	Authenticated	9-Oct-14		
	Weather Data	BCIL_20141007_weather_SQL.csv	Authenticated weather data ready for analysis	Krutsch	Authenticated	9-Oct-14		
	Daily Summary	Manual_Data_Rollup_20141007.xlsx	Collection from roughly 07:30 to 14:30 Contains DIRs 50-006 to 50-008 Contains DITs 50-004 to DIT 50-007 Summary performance data for MANGENs, REDUCE		Limited Use	N/A		

Serial Number	General Category	Filename (if applicable)	Detailed Description	POC	Authentication Code	Date Authenticated	Date Delivered	Comments
Demo1-50-003			DataSet Wednesday 10/08/2014					
	Dashboard Output Data		Authenticated power data ready for analysis	Benasutti				
		BCIL_20141008_MANGEN_N1_DRDdata.csv		Benasutti	Authenticated	9-Oct-14		
		BCIL_20141008_MANGEN_N2_DRDdata.csv		Benasutti	Authenticated	9-Oct-14		
		BCIL_20141008_MANGEN_P1_DRDdata.csv		Benasutti	Authenticated	9-Oct-14		
		BCIL_20141008_MANGEN_P2_DRDdata.csv		Benasutti	Authenticated	9-Oct-14		
		BCIL_20141008_MANGEN_P3_DRDdata.csv		Benasutti	Authenticated	9-Oct-14		
		BCIL_20141008_MANGEN_Q1_DRDdata.csv		Benasutti	Authenticated	9-Oct-14		
		BCIL_20141008_REDUCE1_DRDdata.csv		Benasutti	Authenticated	9-Oct-14		
		BCIL_20141008_REDUCE2_DRDdata.csv		Benasutti	Authenticated	9-Oct-14		
		BCIL_20141008_REDUCE3_DRDdata.csv		Benasutti	Authenticated	9-Oct-14		
		BCIL_20141008_REDUCE4_DRDdata.csv		Benasutti	Authenticated	9-Oct-14		
		BCIL_20141008_REDUCE_Battery_State_of_Charge_DRDdata.csv		Benasutti	Authenticated	9-Oct-14		
		BCIL_20141008_REDUCE_Instantaneous_Generator_Power_Generated_DRDdata.csv		Benasutti	Authenticated	9-Oct-14		
		BCIL_20141008_REDUCE_Solar_Power_Generated_DRDdata.csv		Benasutti	Authenticated	9-Oct-14		
	Weather Data	BCIL_20141008_weather_SQL.csv	Authenticated weather data ready for analysis	Krutsch	Authenticated	9-Oct-14		
	Daily Summary	Manual_Data_Rollup_20141008.xlsx	Collection from roughly 07:30 to 14:30 Contains DIRs 50-009 to 50-010 Contains DIT 50-008 Summary performance data for MANGENs, REDUCE	Krutsch	Limited Use	N/A		

Serial Number	General Category	Filename (if applicable)	Detailed Description	POC	Authentication Code	Date Authenticated	Date Delivered	Comments
Demo1-50-004			DataSet Thursday 10/09/2014					
	Dashboard Output Data		Authenticated power data ready for analysis	Benasutti				
		BCIL_20141009_Billeting_Tent_BLDG05_Combined_PM64_DRD.csv		Benasutti	Limited Use	16-Oct-14		These power data were flagged because the graph appeared different than the other tents. EDVT investigated and found no cause for the discrepancy. (DIT 50-010)
		BCIL_20141009_Billeting_Tent_BLDG05_ECU_PM87_DRD.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141009_Billeting_Tent_BLDG06_Combined_PM54_DRD.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141009_Billeting_Tent_BLDG06_ECU_PM88_DRD.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141009_Billeting_Tent_BLDG07_Combined_PM75_DRD.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141009_Billeting_Tent_BLDG07_ECU_PM89_DRD.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141009_Billeting_Tent_BLDG08_Combined_PM74_DRD.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141009_Billeting_Tent_BLDG08_ECU_PM90_DRD.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141009_Billeting_Tent_BLDG29_OBVPHighPriority_PM56_DRDdata.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141009_Billeting_Tent_BLDG29_OBVPLowPriority_PM79_DRDdata.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141009_Billeting_Tent_BLDG30_OBVPHighPriority_PM59_DRDdata.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141009_Billeting_Tent_BLDG30_OBVPLowPriority_PM30_DRDdata.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141009_Billeting_Tent_BLDG31_OBVPHighPriority_PM70_DRDdata.csv		Benasutti	Authenticated	16-Oct-14		These data were flagged during the DAG due to TC data. The issue is resolved (DIT 50-010).
		BCIL_20141009_Billeting_Tent_BLDG31_OBVPLowPriority_PM76_DRDdata.csv		Benasutti	Authenticated	16-Oct-14		These data were flagged during the DAG due to TC data. The issue is resolved (DIT 50-010).
		BCIL_20141009_Billeting_Tent_BLDG32_OBVPHighPriority_PM71_DRDdata.csv		Benasutti	Authenticated	16-Oct-14		These data were flagged during the DAG due to TC data. The issue is resolved (DIT 50-010).
		BCIL_20141009_Billeting_Tent_BLDG32_OBVPLowPriority_PM77_DRDdata.csv		Benasutti	Authenticated	16-Oct-14		These data were flagged during the DAG due to TC data. The issue is resolved (DIT 50-010).
		BCIL_20141009_MANGEN_N1_DRDdata.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141009_MANGEN_N2_DRDdata.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141009_MANGEN_P1_DRDdata.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141009_MANGEN_P2_DRDdata.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141009_MANGEN_P3_DRDdata.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141009_MANGEN_Q1_DRDdata.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141009_REDUCE1_DRDdata.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141009_REDUCE2_DRDdata.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141009_REDUCE3_DRDdata.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141009_REDUCE4_DRDdata.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141009_REDUCE_Battery_State_of_Charge_DRDdata.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141009_REDUCE_Instantaneous_Generator_Power_Generated_DRDdata.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141009_REDUCE_Solar_Power_Generated_DRDdata.csv		Benasutti	Authenticated	16-Oct-14		
	Weather Data	BCIL_20141009_weather_SQL.csv	Authenticated weather data ready for analysis	Krutsch	Authenticated	16-Oct-14		
	Daily Summary	Manual_Data_Rollup_20141009.xlsx	Collection from roughly 07:30 to 14:30 Contains DIRs 50-011 to 50-017 Contains DIT 50-009 to 50-010 Summary performance data for MANGENs, REDUCE, OBVP/TV2GM, and 30kW baseline generators	Krutsch	Limited Use			

Serial Number	General Category	Filename (if applicable)	Detailed Description	POC	Authentication Code	Date Authenticated	Date Delivered	Comments
Demo1-50-005			DataSet Friday 10/10/2014					
	Dashboard Output Data		Authenticated power data ready for analysis	Benasutti				
		BCIL_20141010_Billeting_Tent_BLDG05_Combined_PM64_DRD.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141010_Billeting_Tent_BLDG05_ECU_PM87_DRD.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141010_Billeting_Tent_BLDG06_Combined_PM54_DRD.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141010_Billeting_Tent_BLDG06_ECU_PM88_DRD.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141010_Billeting_Tent_BLDG07_Combined_PM75_DRD.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141010_Billeting_Tent_BLDG07_ECU_PM89_DRD.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141010_Billeting_Tent_BLDG08_Combined_PM74_DRD.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141010_Billeting_Tent_BLDG08_ECU_PM90_DRD.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141010_Billeting_Tent_BLDG29_OBVPHighPriority_PM56_DRDdata.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141010_Billeting_Tent_BLDG29_OBVPLowPriority_PM79_DRDdata.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141010_Billeting_Tent_BLDG30_OBVPHighPriority_PM59_DRDdata.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141010_Billeting_Tent_BLDG30_OBVPLowPriority_PM30_DRDdata.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141010_Billeting_Tent_BLDG31_OBVPHighPriority_PM70_DRDdata.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141010_Billeting_Tent_BLDG31_OBVPLowPriority_PM76_DRDdata.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141010_Billeting_Tent_BLDG32_OBVPHighPriority_PM71_DRDdata.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141010_Billeting_Tent_BLDG32_OBVPLowPriority_PM77_DRDdata.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141010_MANGEN_N1_DRDdata.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141010_MANGEN_N2_DRDdata.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141010_MANGEN_P1_DRDdata.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141010_MANGEN_P2_DRDdata.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141010_MANGEN_P3_DRDdata.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141010_MANGEN_Q1_DRDdata.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141010_REDUCE1_DRDdata.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141010_REDUCE2_DRDdata.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141010_REDUCE3_DRDdata.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141010_REDUCE4_DRDdata.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141010_REDUCE_Battery_State_of_Charge_DRDdata.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141010_REDUCE_Instantaneous_Generator_Power_Generated_DRDdata.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141010_REDUCE_Solar_Power_Generated_DRDdata.csv		Benasutti	Authenticated	16-Oct-14		
	Weather Data	BCIL_20141010_weather_SQL.csv	Authenticated weather data ready for analysis	Krutsch	Authenticated	16-Oct-14		
	Daily Summary	Manual_Data_Rollup_20141010.xlsx	Collection from roughly 07:30 to 11:30 Contains DIRs 50-018 to 50-028 & 50-054 Contains DITs 50-011 to DIT 50-012 Summary performance data for MANGENs, REDUCE, OBVP/TV2GM, and 30kW baseline generators	Krutsch	Limited Use			

Serial Number	General Category	Filename (if applicable)	Detailed Description	POC	Authentication Code	Date Authenticated	Date Delivered	Comments
Demo1-50-006			DataSet Tuesday 10/14/2014					
	Dashboard Output Data		Authenticated power data ready for analysis	Benasutti				
		BCIL_20141014_Billeting_Tent_BLDG05_Combined_PM64_DRD.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141014_Billeting_Tent_BLDG05_ECU_PM87_DRD.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141014_Billeting_Tent_BLDG06_Combined_PM54_DRD.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141014_Billeting_Tent_BLDG06_ECU_PM88_DRD.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141014_Billeting_Tent_BLDG07_Combined_PM75_DRD.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141014_Billeting_Tent_BLDG07_ECU_PM89_DRD.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141014_Billeting_Tent_BLDG08_Combined_PM74_DRD.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141014_Billeting_Tent_BLDG08_ECU_PM90_DRD.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141014_Billeting_Tent_BLDG29_OBVPHighPriority_PM56_DRDdata.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141014_Billeting_Tent_BLDG29_OBVPLowPriority_PM79_DRDdata.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141014_Billeting_Tent_BLDG30_OBVPHighPriority_PM59_DRDdata.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141014_Billeting_Tent_BLDG30_OBVPLowPriority_PM30_DRDdata.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141014_Billeting_Tent_BLDG31_OBVPHighPriority_PM70_DRDdata.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141014_Billeting_Tent_BLDG31_OBVPLowPriority_PM76_DRDdata.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141014_Billeting_Tent_BLDG32_OBVPHighPriority_PM71_DRDdata.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141014_Billeting_Tent_BLDG32_OBVPLowPriority_PM77_DRDdata.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141014_MANGEN_N1_DRDdata.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141014_MANGEN_P1_DRDdata.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141014_MANGEN_P2_DRDdata.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141014_MANGEN_P3_DRDdata.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141014_MANGEN_P4_DRDdata.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141014_MANGEN_Q1_DRDdata.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141014_REDUCE1_DRDdata.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141014_REDUCE2_DRDdata.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141014_REDUCE3_DRDdata.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141014_REDUCE4_DRDdata.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141014_REDUCE_Battery_State_of_Charge_DRDdata.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141014_REDUCE_Instantaneous_Generator_Power_Generated_DRDdata.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141014_REDUCE_Solar_Power_Generated_DRDdata.csv		Benasutti	Authenticated	16-Oct-14		
	Weather Data	BCIL_20141014_weather_SQL.csv		Krutsch	Authenticated	16-Oct-14		
	Daily Summary	Manual_Data_Rollup_20141014.xlsx	Collection from roughly 09:30 to 14:00 Contains DIRs 50-029 to 50-040 Summary performance data for MANGENs, REDUCE, OBVP/TV2GM, and 30kW baseline generators	Krutsch	Limited Use			

Serial Number	General Category	Filename (if applicable)	Detailed Description	POC	Authentication Code	Date Authenticated	Date Delivered	Comments
Demo1-50-007			DataSet Wednesday 10/15/2014					
	Dashboard Output Data		Authenticated power data ready for analysis	Benasutti				
		BCIL_20141015_Billeting_Tent_BLDG05_Combined_PM64_DRD.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141015_Billeting_Tent_BLDG05_ECU_PM87_DRD.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141015_Billeting_Tent_BLDG06_Combined_PM54_DRD.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141015_Billeting_Tent_BLDG06_ECU_PM88_DRD.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141015_Billeting_Tent_BLDG07_Combined_PM75_DRD.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141015_Billeting_Tent_BLDG07_ECU_PM89_DRD.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141015_Billeting_Tent_BLDG08_Combined_PM74_DRD.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141015_Billeting_Tent_BLDG08_ECU_PM90_DRD.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141015_Billeting_Tent_BLDG29_OBVPHighPriority_PM56_DRDdata.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141015_Billeting_Tent_BLDG29_OBVPLowPriority_PM79_DRDdata.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141015_Billeting_Tent_BLDG30_OBVPHighPriority_PM59_DRDdata.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141015_Billeting_Tent_BLDG30_OBVPLowPriority_PM30_DRDdata.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141015_Billeting_Tent_BLDG31_OBVPHighPriority_PM70_DRDdata.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141015_Billeting_Tent_BLDG31_OBVPLowPriority_PM76_DRDdata.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141015_Billeting_Tent_BLDG32_OBVPHighPriority_PM71_DRDdata.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141015_Billeting_Tent_BLDG32_OBVPLowPriority_PM77_DRDdata.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141015_MANGEN_N1_DRDdata.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141015_MANGEN_P1_DRDdata.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141015_MANGEN_P2_DRDdata.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141015_MANGEN_P3_DRDdata.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141015_MANGEN_P4_DRDdata.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141015_MANGEN_Q1_DRDdata.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141015_REDUCE1_DRDdata.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141015_REDUCE2_DRDdata.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141015_REDUCE3_DRDdata.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141015_REDUCE4_DRDdata.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141015_REDUCE_Battery_State_of_Charge_DRDdata.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141015_REDUCE_Instantaneous_Generator_Power_Generated_DRDdata.csv		Benasutti	Authenticated	16-Oct-14		
		BCIL_20141015_REDUCE_Solar_Power_Generated_DRDdata.csv		Benasutti	Authenticated	16-Oct-14		
	Weather Data	BCIL_20141015_weather_SQL.csv		Krutsch	Authenticated	16-Oct-14		
	Daily Summary	Manual_Data_Rollup_20141015.xlsx	Collection from roughly 07:30 to 14:30 Contains DIRs 50-041 to 50-046 Summary performance data for MANGENs, REDUCE, OBVP/TV2GM, and 30kW baseline generators	Krutsch	Limited Use			

Serial Number	General Category	Filename (if applicable)	Detailed Description	POC	Authentication Code	Date Authenticated	Date Delivered	Comments
Demo1-50-008			DataSet Thursday 10/16/2014					
	Dashboard Output Data		Authenticated power data ready for analysis	Benasutti				
		BCIL_20141016_Billeting_Tent_BLDG05_Combined_PM64_DRDdata.csv		Benasutti	Authenticated	20-Oct-14		
		BCIL_20141016_Billeting_Tent_BLDG05_ECU_PM87_DRDdata.csv		Benasutti	Authenticated	20-Oct-14		The last hour and eight minutes of these data were found to be missing after the file was authenticated. The EDVT harvested the missing data points and inserted them into the file to make the file complete.
		BCIL_20141016_Billeting_Tent_BLDG06_Combined_PM54_DRDdata.csv		Benasutti	Authenticated	20-Oct-14		
		BCIL_20141016_Billeting_Tent_BLDG06_ECU_PM88_DRDdata.csv		Benasutti	Authenticated	20-Oct-14		
		BCIL_20141016_Billeting_Tent_BLDG07_Combined_PM75_DRDdata.csv		Benasutti	Authenticated	20-Oct-14		
		BCIL_20141016_Billeting_Tent_BLDG07_ECU_PM89_DRDdata.csv		Benasutti	Authenticated	20-Oct-14		
		BCIL_20141016_Billeting_Tent_BLDG08_Combined_PM74_DRDdata.csv		Benasutti	Authenticated	20-Oct-14		
		BCIL_20141016_Billeting_Tent_BLDG08_ECU_PM90_DRDdata.csv		Benasutti	Authenticated	20-Oct-14		
		BCIL_20141016_Billeting_Tent_BLDG29_OBVPHighPriority_PM56_DRDdata.csv		Benasutti	Authenticated	20-Oct-14		
		BCIL_20141016_Billeting_Tent_BLDG29_OBVPLowPriority_PM79_DRDdata.csv		Benasutti	Authenticated	20-Oct-14		
		BCIL_20141016_Billeting_Tent_BLDG30_OBVPHighPriority_PM59_DRDdata.csv		Benasutti	Authenticated	20-Oct-14		
		BCIL_20141016_Billeting_Tent_BLDG30_OBVPLowPriority_PM30_DRDdata.csv		Benasutti	Authenticated	20-Oct-14		
		BCIL_20141016_Billeting_Tent_BLDG31_OBVPHighPriority_PM70_DRDdata.csv		Benasutti	Authenticated	20-Oct-14		
		BCIL_20141016_Billeting_Tent_BLDG31_OBVPLowPriority_PM76_DRDdata.csv		Benasutti	Authenticated	20-Oct-14		
		BCIL_20141016_Billeting_Tent_BLDG32_OBVPHighPriority_PM71_DRDdata.csv		Benasutti	Authenticated	20-Oct-14		
		BCIL_20141016_Billeting_Tent_BLDG32_OBVPLowPriority_PM77_DRDdata.csv		Benasutti	Authenticated	20-Oct-14		
		BCIL_20141016_MANGEN_N1_DRDdata.csv		Benasutti	Authenticated	20-Oct-14		
		BCIL_20141016_MANGEN_N2_DRDdata.csv		Benasutti	Authenticated	20-Oct-14		
		BCIL_20141016_MANGEN_P1_DRDdata.csv		Benasutti	Authenticated	20-Oct-14		
		BCIL_20141016_MANGEN_P2_DRDdata.csv		Benasutti	Authenticated	20-Oct-14		
		BCIL_20141016_MANGEN_P4_DRDdata.csv		Benasutti	Authenticated	20-Oct-14		
		BCIL_20141016_MANGEN_Q1_DRDdata.csv		Benasutti	Authenticated	20-Oct-14		
		BCIL_20141016_REDUCE1_DRDdata.csv		Benasutti	Authenticated	20-Oct-14		
		BCIL_20141016_REDUCE2_DRDdata.csv		Benasutti	Authenticated	20-Oct-14		
		BCIL_20141016_REDUCE3_DRDdata.csv		Benasutti	Authenticated	20-Oct-14		
		BCIL_20141016_REDUCE4_DRDdata.csv		Benasutti	Authenticated	20-Oct-14		
		BCIL_20141016_REDUCE_Battery_State_of_Charge_DRDdata.csv		Benasutti	Authenticated	20-Oct-14		
		BCIL_20141016_REDUCE_Instantaneous_Generator_Power_Generated_DRDdata.csv		Benasutti	Authenticated	20-Oct-14		
		BCIL_20141016_REDUCE_Solar_Power_Generated_DRDdata.csv		Benasutti	Authenticated	20-Oct-14		
	Weather Data	BCIL_20141016_weather_SQL.csv		Krutsch	Authenticated	20-Oct-14		
	Daily Summary	Manual_Data_Rollup_20141016.xlsx	Collection from roughly 07:30 to 14:30 Contains DIRs 50-047 to 50-053 Summary performance data for MANGENs, REDUCE, OBVP/TV2GM, and 30kW baseline generators	Krutsch	Limited Use			

Serial Number	General Category	Filename (if applicable)	Detailed Description	POC	Authentication Code	Date Authenticated	Date Delivered	Comments
Demo1-50-009			DataSet Friday 10/17/2014					
	Dashboard Output Data		Authenticated power data ready for analysis	Benasutti				
		BCIL_20141017_Billeting_Tent_BLDG05_Combined_PM64_DRDdata.csv		Benasutti	Authenticated	20-Oct-14		All North Camp and South Camp data for 17 Oct were re-harvested to fill data gaps. These files were authenticated by the EDVT.
		BCIL_20141017_Billeting_Tent_BLDG05_ECU_PM87_DRDdata.csv		Benasutti	Authenticated	20-Oct-14		same as above
		BCIL_20141017_Billeting_Tent_BLDG06_Combined_PM54_DRDdata.csv		Benasutti	Authenticated	20-Oct-14		same as above
		BCIL_20141017_Billeting_Tent_BLDG06_ECU_PM88_DRDdata.csv		Benasutti	Authenticated	20-Oct-14		same as above
		BCIL_20141017_Billeting_Tent_BLDG07_Combined_PM75_DRDdata.csv		Benasutti	Authenticated	20-Oct-14		same as above
		BCIL_20141017_Billeting_Tent_BLDG07_ECU_PM89_DRDdata.csv		Benasutti	Authenticated	20-Oct-14		same as above
		BCIL_20141017_Billeting_Tent_BLDG08_Combined_PM74_DRDdata.csv		Benasutti	Authenticated	20-Oct-14		same as above
		BCIL_20141017_Billeting_Tent_BLDG08_ECU_PM90_DRDdata.csv		Benasutti	Authenticated	20-Oct-14		same as above
		BCIL_20141017_Billeting_Tent_BLDG29_OBVPHighPriority_PM56_DRDdata.csv		Benasutti	Authenticated	23-Oct-14		same as above
		BCIL_20141017_Billeting_Tent_BLDG29_OBVPLowPriority_PM79_DRDdata.csv		Benasutti	Authenticated	23-Oct-14		same as above
		BCIL_20141017_Billeting_Tent_BLDG30_OBVPHighPriority_PM59_DRDdata.csv		Benasutti	Authenticated	23-Oct-14		same as above
		BCIL_20141017_Billeting_Tent_BLDG30_OBVPLowPriority_PM30_DRDdata.csv		Benasutti	Authenticated	23-Oct-14		same as above
		BCIL_20141017_Billeting_Tent_BLDG31_OBVPHighPriority_PM70_DRDdata.csv		Benasutti	Authenticated	23-Oct-14		same as above
		BCIL_20141017_Billeting_Tent_BLDG31_OBVPLowPriority_PM76_DRDdata.csv		Benasutti	Authenticated	23-Oct-14		same as above
		BCIL_20141017_Billeting_Tent_BLDG32_OBVPHighPriority_PM71_DRDdata.csv		Benasutti	Authenticated	23-Oct-14		same as above
		BCIL_20141017_Billeting_Tent_BLDG32_OBVPLowPriority_PM77_DRDdata.csv		Benasutti	Authenticated	23-Oct-14		same as above
		BCIL_20141017_MANGEN_N1_DRDdata.csv		Benasutti	Authenticated	20-Oct-14		
		BCIL_20141017_MANGEN_N2_DRDdata.csv		Benasutti	Authenticated	20-Oct-14		
		BCIL_20141017_MANGEN_P1_DRDdata.csv		Benasutti	Authenticated	20-Oct-14		
		BCIL_20141017_MANGEN_P2_DRDdata.csv		Benasutti	Authenticated	20-Oct-14		
		BCIL_20141017_MANGEN_P4_DRDdata.csv		Benasutti	Authenticated	20-Oct-14		
		BCIL_20141017_MANGEN_Q1_DRDdata.csv		Benasutti	Authenticated	20-Oct-14		
		BCIL_20141017_REDUCE1_DRDdata.csv		Benasutti	Authenticated	20-Oct-14		
		BCIL_20141017_REDUCE2_DRDdata.csv		Benasutti	Authenticated	20-Oct-14		
		BCIL_20141017_REDUCE3_DRDdata.csv		Benasutti	Authenticated	20-Oct-14		
		BCIL_20141017_REDUCE4_DRDdata.csv		Benasutti	Authenticated	20-Oct-14		
		BCIL_20141017_REDUCE_Battery_State_of_Charge_DRDdata.csv		Benasutti	Authenticated	20-Oct-14		
		BCIL_20141017_REDUCE_Instantaneous_Generator_Power_Generated_DRDdata.csv		Benasutti	Authenticated	20-Oct-14		
		BCIL_20141017_REDUCE_Solar_Power_Generated_DRDdata.csv		Benasutti	Authenticated	20-Oct-14		
	Weather Data	BCIL_20141017_weather_SQL.csv		Krutsch	Authenticated	20-Oct-14		
	Daily Summary	Manual_Data_Rollup_20141017.xlsx	Collection from roughly 07:30 to 13:00 Contains DIRs 50-055 to 50-060 Summary performance data for MANGENs, REDUCE, 30kW-TQG/TV2GM, and 30kW baseline generators	Krutsch	Limited Use			

ANNEX B – Soldier Focus Group Summary

(Reprint of original)

The following report was prepared and submitted by Justine Federici and Caelli Craig.

1 Introduction

SLB-STO-D requested support from the Consumer Research Team (CRT) to conduct a focus group on the four technologies included as part of the 50 personnel camp demonstration located at the Base Camp Integration Lab (BCIL). The goal of these focus groups was to collect qualitative feedback from Soldiers who had trained and spent time operating the systems. Seven Army reservists from the 542nd Quartermaster Company participated in these focus groups that were conducted on 17 October 2014.

2 Methods & Participants

Soldiers met with a research psychologist from the CRT in order to discuss the four candidate technologies. A general outline was followed, which listed topics to be discussed during the focus groups such as maintainability of the system, best uses of the system, ideal camp size for the technology, as well as recommendations for improvement. Soldiers were asked to give candid feedback in order to help improve the acceptability of the systems. Notes were taken by a member of the CRT and summarized in the report. Participants' ages ranged from 22-57 years, with a mean of 30.71 years. Their ranks were PFC (n=1), SPC (n=3), and SGT (n=3). Years in service ranged from 3-18 years, with a mean of 8.57 years. Their MOSs were 92S (shower/laundry & clothing repair), 91D (power generation equipment repair), 88K (watercraft operator), 92A (automated logistical specialist), and 92F (petroleum supply specialist). The Soldiers were divided into two 2-man teams, and one 3-man team, and spent three days rotating across the three candidate technologies (one day per technology).

FOCUS GROUP PARTICIPANTS				
	AGE	RANK	MOS	YEARS IN SERVICE
1	32	E-5	92S	11
2	57	E-5	88K	18
3	23	E-4	92S	3
4	24	E-3	91D	5
5	22	E-4	92A	5
6	27	E-5	91D	6
7	30	E-4	92F	12
AVERAGE:	**30.71**	**E-3 to E-5**		**8.57**

3 Results

3.1 Renewable Energy for Distributed Under-supplied Command Environments (REDUCE)

The Soldiers gave candid feedback on the REDUCE system during the focus groups. One aspect of the system that they liked was the relatively short amount of time it would take to set up and maintain the REDUCE system. They said it would take about 15-20 minutes, which meant that “not a lot of effort or time” was required to maintain this system. They also said that although they have to do everything as a two-man team, the set-up could be done with one person because it’s “not complicated…very nice” and because the “operation is straightforward.” It was also shared that their “gut feeling” was that that this system would require “little maintenance.”

Another feature of the system that the Soldiers liked was the solar panels. They liked that damage to a panel would only shut down a specific row of the system and not the entire panel. An additional benefit mentioned is that the system is quiet when the onboard generator is not running. During this demonstration exercise, the onboard generator ran very little. They said that this system is much quieter than typical generators, which is a tactical benefit. One Soldier said that he “would like a quieter environment, which REDUCE gives, but you still need TQGs (Tactical Quiet Generator) for fallback.”

During this demonstration, the REDUCE system was used to power the tactical operations center (TOC). Soldiers were asked if this was a logical use of the REDUCE system and/or where else on the camp they would recommend using the system. Soldiers said that it looks “sufficient” to power a TOC or small command center and that the “TOC is a good place to put it.” However, the Soldiers qualified these statements by saying that the system should only be used to power important things (phones, computers, charging batteries, running radio sets): “you always want these [command centers] running… you want communications running.” They did not believe that the HVAC in the TOC should be powered with this system because HVAC is “too big of a load.”

The Soldiers had some concerns about using the REDUCE to power a TOC in a deployment. They believed the size of the REDUCE may make it a target for a camp at the base of a mountain: “it’s like ‘oh that’s their power, we’ll take that out and they’ll lose communications.’” And because of the nature of solar panels, creating a protective barrier around the panels is not feasible, which makes them even more vulnerable to attack: “Hescos would block the bottom of the solar panels, so they can’t be used.” As a result of these vulnerabilities, the Soldiers said that using the REDUCE would be a “good way to go”

in remote areas or in training situations. They were also concerned that due to the size of the system, they would only be able to bring 1-3 REDUCE systems on a truck as compared to 8 TQGs, which would fit in the same amount of space on a truck[1].

The Soldiers believed that repairing the system when deployed has the potential to be problematic. They raised the issue of the logistics involved in getting replacement parts when they are overseas. They said: "you can't just call vendors from overseas." Because of this, the Soldiers believe that the REDUCE system would never be able to replace TQGs since they can't wait to get solar panels replaced whenever they break: "REDUCE isn't going to replace TQGs… it's a nice addition, but there's no way of getting rid of TQGs." The Soldiers also said that commercial generators are more fuel efficient, but "we have the parts for our stuff [TQGs]," so part availability is an important thing to consider when developing new systems. They also mentioned that "familiarity with the system is important," and pointed out that new technologies can be difficult to implement due to a lack of knowledge of the system.

Another issue the Soldiers voiced was that the wind turbines on the system cast a shadow on the solar panels, which causes this portion of the panels not to work. The Soldiers suggested moving the wind turbines to the back of the system to prevent shadows being cast on the panels. One Soldier asked if the wind turbine could charge more than 1 set of batteries: "could you trickle charge to both sets [of batteries]?" He suggested that, if possible, there should be a cut-off so that once one set of batteries is charged, it switches to the other set of batteries.

The Soldiers explained that the generators will "go without a load for 30 seconds and then the load all goes on… you see black smoke because there's not enough warm up time, it just slams the load on it." They said that "if the battery could charge itself more intelligently, that would be a great improvement." The Soldiers also did not like that the system utilizes lead acid batteries. One Soldier said that you could "cut 400 pounds by changing batteries."

The Soldiers pointed out that they were unable to see the fuel gauge on the generator, and that if the generator was not level, the gauge would be inaccurate. They suggested putting something on the generator that makes it easy to check the fluid levels.

The Soldiers then discussed the touch screens on the generators, and although the screens were okay with glare, they were worried that the touch screens might not hold up well in desert conditions and therefore suggested to have buttons or a keyboard instead: "How well would they last in the desert? Sandstorms happen so maybe have a screen but have everything run with buttons or keyboard like the TQG."

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[1] It should be noted that the number of REDUCE systems and/or TQG's have not been verified. This estimation is based on Soldier opinion.

3.2 Man-Portable Genset for Power Generation (MANGEN) for Expeditionary Small Unit Operations (ESUO)

Three prototype generators were included in the demonstration and discussed during the focus group: PCI (camo, 1 button), QinetiQ (green, 3 buttons), and Novatio (red, 1 button).

The MANGENs were well received by the Soldiers, who all had many positive things to say about them. All of the Soldiers agreed that the generators are a good idea and described them as “simple, lightweight, and easy to operate.” They also said that “anybody could use them… they’re easy to use and easy to operate,” “easy to move around, not heavy at all,” “good for mobility, good for power sources,” and “having power as a back-up is always a good thing.”

When asked in what context they would use the generators, they responded they would use them to power lights when they “first roll onto the scene” and to “charge man packs, hand radios,” and for “use in guard towers.” They also said they’re good for when you “need something close to you… you could use this instead of using an extension cord. For example, in the motor pool if you need a light.” The Soldiers believe these generators would mainly be used in guard towers or motor pools, therefore a camp would not require many of them as they could be shared amongst people and moved to different areas as needed. More specifically, the Soldiers said that they would need “maybe five for a 300 man camp, or six so that they could be doubled up in parallel.” One Soldier added that these portable generators are “more of a convenience” and are therefore nice to have but not necessary.

Another context for using the generators would be to include them in HMMWV’s: “all of us thought of having it attached to a HMMWV or made as an integrated part of some HMMWV.” They believe it will reduce “wear and tear” on the HMMWV battery, which happens whenever Soldiers charge equipment through the HMMWV.

The Soldiers were then asked which of the three generators they preferred and why. Three Soldiers preferred the PCI generator, while three had no preference. Soldiers liked the PCI generator because it was “easy to use” and they liked the clearing button because they were able to consistently start the generator after pressing it. Those who had no preference said that “all three had something that the others didn’t,” “whole concept in general is good… can’t really pick one of the three.” The Soldiers stated that they used the Novatio generators in parallel in order to run the Dining Facility. This capability (running generators in parallel) is something the Soldiers would like to be able to do because it prevents them from having to use a much larger generator. One Soldier commented that he liked the QinetiQ generator because it “has multiple switches so then people can’t take them for personal use.” In

response to this, one Soldier said that “that’s the point [personal use]” of the smaller generators and that the “simpler the better.” He said that anyone should be able to operate these generators.

The Soldiers then provided some recommendations for improvement. One recommendation was to make the battery external to the system so that it is easily accessible. The Soldiers also suggested adding a weather cover on the front of the system or including a cinch bag that would be able to protect the generator against inclement weather. The Soldiers also thought a whisper quiet mode would be beneficial. Comments were then made by the Soldiers about the auxiliary fuel line, which they said needed improvement because it is currently made of thin plastic which split. They suggested using a Teflon material or other fuel-appropriate hose and specified that a high pressure fuel line would not be necessary. They also suggested having a low fuel buzzer/indicator or a way to switch to the auxiliary fuel line so the generator doesn’t cut off. All of the Soldiers agreed that “screws are bad and not good in the field.” They suggested trying to lessen or eliminate the use of screws in the generators.

Finally, the Soldiers would like fault indicators for the portable generators as well such as a diagnostic program on a CD to run and diagnose problems. One Soldier explained: “no matter what, there has to be some sort of disc with it to see faults. There’s always a laptop in the field to hook up to install and find a fault. A USB port would be useful to hook up to a laptop. Maybe even create an app to hook up to check faults.”

3.3 On-Board Vehicle Power/Tactical Vehicle-to-Grid Module (OBVP/TV2GM)

Overall, the Soldiers’ comments about this system were very positive. While testing this system, the Soldiers were also using TQGs. All of the Soldiers thought the system was “fantastic.” More specifically, the Soldiers found the system to be flexible and convenient. They made statements such as: “very convenient… convenience is fantastic because we already have the vehicle,” “great because we’re already taking vehicles wherever we go,” “like that it’s easily deployable because it’s vehicle based,”“good to have vehicle with [power]generation capability,” and “good for flexibility.”

When asked during what types of situation they would use this system, they responded that they would use it during the initial stages of setting up a base camp. For instance, they would use the system while setting up a tent to power the HVAC and lights. They said they would use it at any size camp, and believe it “could power a whole 50 man camp.” The Soldiers said it managed the load well and liked that the system could be off-loaded from a vehicle and used with TQGs. They also liked that “there are two sources of power because we can off-load and use the HMMWV itself for power as well.”

The Soldiers also raised some concerns they had about the system. The Soldiers believe the system could cause more “wear and tear” on a HMMWV because the vehicle is stationary, and therefore is not

being moved normally. Another potential issue is the startup time for the system, which Soldiers said was long (5 minutes to boot software and 5-10 minutes to start up the high voltage trail). They would like the startup time to be reduced to 2-3 minutes instead of 10-15 minutes overall.

Temperature regulation in tents while using this system was also an area of concern for the Soldiers. The Soldiers did not like that the system cycles on and off and were concerned that the “tents heat up fast in extreme heat, 20 minutes on and 20 minutes off might be bad.” They thought that these time increments might not regulate the temperature well enough in extreme climates. One Soldier then said that “temperature control is most important when sleeping… we can suck it up other times.[2]”

Another concern voiced by the Soldiers is if the system is run next to sleeping quarters. They said that exhaust from the HMMWV being run next to sleeping quarters must include a method for pumping the exhaust away from the tents. (NOTE added by the EDVT: The OBVP was installed next to the billeting shelter due to space constraints within the BCIL for the demonstration. There was no intent to imply that this was an operational solution and this should have been explained to the Soldiers. No personnel occupied these shelters during the demonstration. The Soldiers were correct to point out that vehicle exhaust near the shelters is a risk that must be mitigated.) They also said it “would be nice to be able to tweak the voltage on the distribution units.” Some of the Soldiers said that the software “seems behind the system… laggy.” These Soldiers also suggested having pop-ups that would tell them more details about faults with the system.

Lastly, many of the Soldiers commented that they had accidentally shut the generator off using the emergency stop button because the button was either not covered or because it was right next to a button they were trying to push. They suggested adding a cover over the emergency stop button or adding a prompt message that pops up whenever the emergency stop is pressed (e.g. “Is this really what you want to do?”).

3.4 Non-woven Composite Insulation Liner

The Soldiers did not have many comments about the liner, as they did not set up the liners during the demonstration. However, one Soldier had used the liners in the past and said the “toggle closures” or attachments work better than the original Velcro closures. He also said that the “biggest thing is weight… once you get to the middle [while putting up the liner], it’s hard to hold up.” All of the Soldiers would like something over the windows to block out rain. Finally, some noted that the liner started to rip with a snow load after everything was installed.

[2] It should be noted that the system was set to a 20 minute cycle which can be adjusted.